# SCIENCE ABSTRACTS.

## Section A.—PHYSICS.

## OCTOBER 1915.

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# SCIENCE ABSTRACTS.

## Section A.—PHYSICS.

### OCTOBER 1915.

## GENERAL PHYSICS.

**1354.** *A Thermodynamic Integrator.* **R. Gans** and **A. P. Miguez.** (Phys. Zeits. 16. pp. 247–251, July 15, 1915.)—This paper contains complete theoretical and mechanical details of an apparatus for integrating the well-known thermodynamic equation $A - U = T dA/dT$, where A is the free energy, T the absolute temperature, and U the decrease in total energy, which integration may be expressed by the formula $A = -T\int_c^T U/T^2 dT$. Numerous diagrams and curves illustrate the paper, and an example is given of the A-curve as constructed by the apparatus for the chemical affinity between silver and iodine. The operation of integration by this apparatus only takes a few seconds to perform. H. H. Ho.

**1355.** *An Eight-day mechanically recording Rain-gauge.* **C. F. Marvin.** (Monthly Weather Rev. 43. pp. 26–28, Jan., 1915.)—In order to obtain an 8-day record while maintaining a moderate size for the chart, falling rain is arranged to give the pen an alternate rising and falling movement across a portion of the chart ½ in. in width. Thus if the pen is at the bottom of the chart when rain commences, after ¼ in. has fallen it will have passed up the paper in a normal manner to the upper limit of its travel, then during the next ¼ in. the motion is reversed and the pen returns to the lower edge; it then commences to rise again and so on. This serves to compress the record into a ribbon of the chart ½ in. wide, the scale of the gauge being double the natural scale. In order to obtain 8 days' record without unduly decreasing the time scale, the clock drum is made to rotate under the pen with endwise as well as angular motion, so that when no rain is falling the curve takes a spiral form upon the drum. The latter makes one complete turn per day and the daily displacement laterally is ½ in., so that the width of chart covered in 8 days is 4 in. The charts actually measure 20 in. by 5¼ in. and their appearance is made clear by a specimen record reproduced in the original article, the mechanism being also described and illustrated. It is to be noted that no automatic siphoning device is fitted, but the float chamber must be emptied by the observer as often as may be necessary. J. S. Di.

1356. *Amplitudes in a Fourier Series.* **W. H. Dines.** (Nature, 95. pp. 644–645, Aug. 12, 1915.)—Discusses the probable error of the amplitudes in a Fourier series obtained from a given set of observations. Suppose we have a set of $n$ well-distributed observations, and that nothing is known about them in regard to their periodic variation. Let their standard deviation be $\sigma$. Now let the first three terms of the Fourier series be found in the usual way, and let the amplitudes be $a_1$, $a_2$, and $a_3$. The question that arises is, to what extent do $a_1$, $a_2$, and $a_3$ represent genuine periodic variations? The standard deviation may be due entirely to the periodic variations, or may be purely casual. In the former case it is easily proved that $\sigma = \sqrt{(a_1^2 + a_2^2 + a_3^2)}/\sqrt{2}$, and if this relationship is approximately satisfied, the larger amplitudes may be accepted as correct. But if the deviation $\sigma$ of the observations is distinctly larger than that produced by the periodic part, the casual part of it will lead to error in the $a_1$, $a_2$, and $a_3$, and unless an amplitude when compared with $\sigma\sqrt{2}/\sqrt{n}$ is well outside the limits for the special values given, it need not be significant. It follows that the amplitude of any term in a sine curve deduced from only a moderate number of observations must be received with caution until an investigation of its probable error has been made, and this remark refers especially to the second and higher terms where the amplitudes are so often small. A. W.

1357. *Fixing the Elastic Limit Standard.* **T. D. Lynch.** (Mech. Eng. 36. pp. 97–99, Aug. 6, 1915. Abstract of paper read before the Am. Soc. for Testing Materials, June, 1915.)—The author discusses the indefiniteness of the term "elastic limits" as used by engineers and metallurgists, and points out that no fewer than ten terms are used to denote values which lie indefinitely between the limit of proportionality and the yield-point of a metal. A number of complete tensile tests made on samples of the same steel subjected to different heat-treatments indicate that there is a real difference of varying magnitude between the limit of proportionality and the yield-point, and emphasise the importance of definiteness in the use of the terms which designate the quality of steel under stress. F. C. A. H. L.

1358. *Charpy Impact Test on Treated Steels.* **J. J. Thomas.** (Mech. Eng. 36. pp. 107–108, Aug. 6, 1915. Abstract of paper read before the Am. Soc. for Testing Materials, June, 1915.)—Charpy impact tests have been made on alloy and plain carbon steels with the object of determining how the shock-resisting properties can be varied by heat treatment. The results indicate that no reliable information can be obtained from the results of a single test; it is desirable to take the mean of from 4 to 6 tests. The max. resistance to shock in all classes of steels appears to be obtained by quenching followed by tempering at about 650° C. Quenching after tempering appears to decrease the shock strength of heat-treated steels, probably owing to internal stresses being set up consequent upon unequal cooling. Forging seems to confer a toughness upon steel which cannot be obtained by heat treatment alone. Experiments made with a view to determining the effect of the shape of the notch indicate that sides may be flared to an angle of 8° without introducing an appreciable error. F. C. A. H. L.

1359. *Compressibilities of the Elements and their Relations to Other Properties.* **T. W. Richards.** (Am. Chem. Soc., J. 37. pp. 1643–1656, July, 1915.)—Taking the compressibility of mercury at 20° as $3·95 \times 10^{-6}$ [see Abs. 628 (1915)], the author has recalculated the compressibilities of 38 elements, of which 35 are solid and 3 liquid, under the conditions of measurement [see Abs. 1173, 1174 (1903)]. The values are expressed in terms of the average fractional change of volume caused by a pressure of 1 megabar between 100 and 500 megabars, referred to the volume of the uncompressed substance. A table is given showing also the atomic volumes, densities, absolute melting-points, coefficients of expansion, and international atomic weights. Curves are drawn representing the reciprocals of the absolute melting-points, the cubic coefficients of expansion, the atomic volumes, and the compressibilities of the elements as functions of their atomic weights. The close parallelism exhibited by these four curves suggests the existence of a fundamental connection between the corresponding properties. A preliminary attempt to establish a mathematical relationship leads to the expression, $\beta = Kf_1(A)/f_2(D)f_3T_m$, where $\beta$ is the compressibility, A the atomic weight, $T_m$ the absolute melting-point, D the density, K is an empirical constant, and $f_1$, $f_2$, and $f_3$ are various functions of the magnitudes in question. The simplest trial equation giving reasonably good results is, $\beta = 0·00021A/D^{1·25}(T_m - 50°)$. This equation yields discrepant numbers in certain cases, more especially with those elements which exhibit divergence from Dulong and Petit's law.

The low value of the atomic volume of tungsten in comparison with its high atomic weight and the elevated melting- and boiling-points of this element all point to the probable possession of marked cohesiveness and, consequently, of low compressibility, and the latter is found to be the case, tungsten having a smaller compressibility, namely $0·27 \times 10^{-6}$, than any other element carefully studied.

The evidence at present available seems to show that at one and the same temperature liquids are usually far more compressible than the corresponding solids [see Abs. 1029 (1914)]. Thus, the compressibilities of solid ortho- and para-cresols are only about one-half of those of the supercooled liquids under similar conditions. T. H. P.

1360. *Effect of End Connections on Stress Distribution in Single- and Double-angle Tension Members.* **C. Batho.** (Frank. Inst., J. 180. pp. 129–172, Aug., 1915.)—Describes the results of experiments on angle tension members, the distribution of stress being investigated by means of a simple form of Martens mirror extensometer which proves very suitable for the purpose, being compact and robust while capable of measuring strains to 1/100,000 in. on a length of 2 in. A short account is given of the theory on which the analysis of the results is based. The specimens tested were three in number, two single-angle members and one double-angle; these were bolted to gusset plates and were tested both with and without lock angles. The distribution of stress over both central and end sections was found and is shown graphically in the paper. The conclusions reached as a result of the experiments are as follows:—(1) The stress distribution may be assumed to be planar in the sections considered, except, perhaps, close to the ends, and hence the ordinary theory is applicable for the analysis of the stress distribution. (2) In tension members of the forms considered, riveted at their ends to wide and rigidly held gusset plates, the stiffness of the gusset plate in its own plane has a considerable effect on the stress distribution in the member, there being in every case a particular degree of stiffness which will give the least max. stress for a given load. (3) In such members lock angles are of very little use either for giving a more equable distribution of stress in the member or for increasing the effective length of end connections. (4) A slight change in the line of application of the load to the gusset plates does not materially affect the distribution of stress in the member, except, possibly, close to the end connections. (5) Double-angle members do not act as a single piece bending as a beam. (6) In double-angle members with a stiff end-plate the stress is almost uniformly distributed at the central section. J. W. T. W.

1361. *Elastic "After-effect" and Hysteresis.* **E. Warburg** and **W. Heuse.** (Deutsch. Phys. Gesell., Verh. 17. Nos. 11 and 12. pp. 206–213, June 30, 1915. Communication from the Physikal.-Techn. Reichsanstalt.)—If the elastic "after-effect" is the only cause of the hysteresis loop, this loop should disappear if the cycles are performed exceedingly slowly; but this is found not to be the case, and there is therefore a real elastic hysteresis exactly analogous to the magnetic hysteresis. The object of the experiments described in this paper is to separate the effects due to these two causes. The experiments were made by loading plates of steel, German silver, and ebonite, and taking these round a cycle of loads at two widely different speeds. It is found that in the case of German silver with a half-period of 160 mins. the true hysteresis effect is much greater than that due to the "after-effect," while in the case of ebonite this is not the case. The smallness of the effects in steel does not allow of any conclusions from the results obtained. J. W. T. W.

1362. *Temperature Coefficient of Young's Modulus for Iron.* **E. P. Harrison** and **S. K. Chakravarti.** (Phil. Mag. 30. pp. 373–380, Sept., 1915.)—Several observers have found that for loads below a certain magnitude the value of Young's modulus for metal wires reaches a maximum at a temperature of about 100° C. when the heating is performed electrically. This effect was not observed in previous experiments on Ni by one of the authors [see Abs. 151 (1915)], and the present research was undertaken with the object of directly investigating this point. Iron wire was used, one of the test portions being annealed at 400° C. and the other being left unannealed. The wire was heated by the passage of an electric current along it. It is calculated that provided the temperature is constant to 0·3 deg. C. (and the results of experiments in which the temperature varied by more than this were rejected) the measurements of the modulus are correct to about 1·6 %. The results obtained show that in both specimens of wire the isothermal modulus decreases continuously as the temperature rises, there being no indication of a maximum within the range of load (12–25·6 kg.) and temperature (27° to 140° C.) employed. For the annealed specimen $E_\theta/E_{30} = 1 - 0{\cdot}000934(\theta - 30) - 0{\cdot}000{,}000{,}783(\theta - 30)^2$, where $E_{30} = 18{\cdot}95 \times 10^{11}$ dynes/cm.². All the load-elongation graphs are linear within the limits of experimental error.

J. W. T. W.

1363. *Effects of Heat and Work on the Mechanical Properties of Metals.* **A. K. Huntington.** (Inst. of Metals, J. 13. pp. 23–53; Disc. and Corres., 54–79, 1915. Engineering, 99. pp. 334–338, March 19, 1915.)—Alternating bending tests have been made on a number of coppers and copper alloys containing the whole of the added metals in solid solution. The test consisted in determining the number of revolutions required to start cracking and to produce fracture at various temperatures up to 400° C. The results show that the breaking curves are parallel to the curves for initial cracking. The curves show a number of maxima and minima suggesting periodicity in the mechanical properties of the metals, but whether they are all due to allotropic changes or not is an open question. These maxima and minima are greatly reduced by annealing, indicating the important part played by "work" in emphasising transformation-points. The temperature at which copper will anneal is largely influenced by the presence of other metals in solid solution. When plotted together there is a very close agreement between the alternating-stress curves and the yield-point and contraction curves determined by simple tension tests. The varying stresses and strains set up in mechanical testing cause the metal rapidly to assume the condition of equilibrium at any particular temperature. The paper concludes with abstracts of the work of Robin, Pisati, and Le Verrier, whose results point to the correctness of the author's conclusions with regard to the periodicity of the properties of metals and alloys. F. C. A. H. L.

1364. *Stability of the Simple Shearing Motion of a Viscous Incompressible Fluid.* **Rayleigh.** (Phil. Mag. 30. pp. 329–338, Sept., 1915.)—Mathematical.

1365. *Propellers.* **Schaffran.** (Zeits. Vereines Deutsch. Ing. 59. pp. 833–840, April 24, 1915.)—Describes a systematic research on the effect of variations of blade shape, etc., on the efficiency of propellers. The chief interest of the paper lies in the numerous tables and diagrams of results. A. W.

1366. *Some Novel Laboratory Experiments.* **F. W. Jordan.** (Phys. Soc., Proc. 27. pp. 461–475, Aug., 1915.)—Six different experiments are described under the following headings: Condensation calorimeters for measurement of latent and specific heats; Thermal conductivity of a narrow metal bar; Measurement of Poisson's ratio for a rectangular lathe; Measuring coincidence period of a Kater and a clock pendulum; Differential telephone; Interference fringes. For details the original pages must be referred to. L. H. W.

1367. *Smallest Mercury Spherules.* **F. Ehrenhaft.** (Phys. Zeits. 16. pp. 227–237, June 15, 1915.)—A defence of the author's work against the criticism of A. Schidlof and A. Karpowicz. The paper includes five microphotographs of the spherules and a scale for comparison. [See Abs. 981, 1091 (1915).] [*Errata* (Ibid. p. 288, Aug. 1, 1915).] E. H. B.

1368. *Principle of Similitude.* **D. Riabouchinsky.** (Nature, 95. p. 591, July 29, 1915.)—In a treatment of this principle Rayleigh gave the formula $h = \kappa a\theta \,.\, \mathrm{F}(avc/\kappa)$, considering heat, temperature, length, and time as four "independent" units.

If we suppose that only three of these quantities are "really independent" we obtain a different result. For example, if the temperature is defined as the mean kinetic energy of the molecules, the principle of similitude only allows us to affirm that $h = \kappa a\theta \,.\, \mathrm{F}(v/\kappa a^2, ca^3)$. [See Abs. 533 (1915).] E. H. B.

1369. *Paths of Particles for Motions of Frictionless Fluid in a Rotating Enclosure.* **W. B. Morton** and **J. Vint.** (Phil. Mag. 30. pp. 284–287, Aug., 1915.)—In a paper by Morton (Abs. 1776 (1913)] drawings were given of the paths of the liquid particles in some cases of two-dimensional motion. The present paper supplements the former treatment of rotating cylinders, and then passes on to the discussion of some three-dimensional paths which occur in the rotation of an ellipsoidal shell containing liquid.

Models of the curves were made in lead wire and stereoscopic photographs taken, some of which are reproduced. E. H. B.

1370. *Purely Dynamical Foundation of Relativity.* **G. D. Mattioli.** (Accad. Lincei, Atti, 23. pp. 427–432, Nov. 18, 1914. N. Cimento, 9. pp. 263–270, March–April, 1915.)—Shows how, by a new definition of momentum, the relativity transformations may be obtained without starting from electromagnetic equations. The classical momentum is not the limit towards which its relativity expression tends on reducing the velocity of the system indefinitely. The somewhat confused and fragmentary exposition of Laue can be improved by eliminating its electromagnetic setting. E. E. F.

1371. *Hydrodynamical Problems suggested by Pitot's Tubes.* **Rayleigh.** (Roy. Soc., Proc. 91. pp. 503–511, Aug. 2, 1915.)—A mathematical treatment of two problems suggested by the use of Pitot's tubes. The fluid is supposed frictionless, and the circular tube is supposed to be replaced by its two-dimensional analogue, the channel between parallel plane walls. The first problem may be defined as the flow of electricity in two dimensions when the uniformity is disturbed by the presence of a channel whose infinitely thin non-conducting walls are parallel to the flow. By themselves these walls, whether finite or infinite, would cause no disturbance, but the channel, though open at the finite end, is supposed to be closed at an infinite distance away, so that, on the whole, there is no stream through it. If we suppose the flow to be of liquid instead of electricity, the arrangement may be regarded as an idealised Pitot tube, although we know that, in consequence of the sharp edges, the electrical law would be widely departed from. In the recesses of the tube there is no motion, and the pressure developed is simply that due to the velocity of the stream. The problem is treated as a modification of that of Helmholtz, where flow is imagined to take place within the channel and to come to evanescence outside at a distance from the mouth. In the second form of the problem it is supposed that the infinite velocity at the edge, encountered when the fluid adheres to the wall, is obviated by the formation of a surface of discontinuity, where the condition to be satisfied is that of constant pressure and velocity. Solutions of these two problems are given. A. W.

1372. *Surface Tensions of Water, Methyl, Ethyl and Isobutyl Alcohols, Ethyl Butyrate, Benzene, and Toluene.* **T. W. Richards** and **L. B. Coombs.** (Am. Chem. Soc., J. 37. pp. 1656–1676, July, 1915.)—The authors have endeavoured to ascertain the causes of the divergent values obtained by different investigators for the surface tensions of liquids. The method employed by them consisted in measuring the rise of the liquid in capillary tubes, this being one of the most direct methods and also the least likely to lead to unsolvable mathematical complications. Special attention was paid to the measurement of the diam. of the capillary tubes used and to the lighting and observation of the meniscus, in order that the exact position of the bottom of the meniscus might be determined. Concerning the necessary diam. of the wide tube into which the capillary dips, some difference of opinion prevails. In order that the meniscus in this wide tube may have a flat central portion, it is found that the diam. should be at least 38 mm. Neither the expression of

Poisson (1831) nor that of Hagen and Desains (1857) for calculating the height of the meniscus gives satisfactory results, and the authors deduce the equation, $h = h_0 + nh_m$, where $h$ is the true corrected height of the liquid, $h_0$ the observed height, $h_m$ the height of the capillary meniscus, and $n$ a fraction varying from exactly $\frac{1}{3}$ with very narrow tubes (diam. 2·02 mm. or less) to about $\frac{1}{4}$ with wide tubes. Inequalities in the tubes used were detected and corrected by the use of reversible apparatus.

The following values were obtained for the capillary constants at 20°: Water, 14·861; benzene, 6·721; toluene, 6·743; methyl alcohol, 5·882; ethyl alcohol, 5·765; isobutyl alcohol, 5·823; ethyl butyrate, 5·704. T. H. P.

1373. *The Drop-weight Method for determination of Surface Tension of a Liquid.* **J. L. R. Morgan.** (Am. Chem. Soc., J. 37. pp. 1461–1467, June, 1915.)—In a large range of cases there is a very exact proportionality between the drop-weight of a liquid from a given "tip" and its surface tension as derived from the best measurements made by the method of capillary-rise; the agreement is so close in 70 cases, that the less satisfactory agreement in the remaining 30 cases may be due to errors in the measurement of capillary-rise; the data given by the drop-weight are therefore put forward provisionally as a sound basis for calculations of surface tension. The conditions under which drop-weight and surface tension are proportional have been worked out in detail in a series of earlier papers, but are now set out again as part of a critical review of the method. T. M. L.

1374. *The Capillary Layer and Avogadro's Number.* **G. Bakker.** (Zeits. Phys. Chem. 89. pp. 1–48, 1914.)—A theory of capillarity is developed on the assumption of Laplace and Gauss that any substance is a medium or agent of continuous extension, but the author differs from Gauss as to the interpretation of surface tension, and from both in his deductions. The theory agrees with the experimental data of various observers concerning a large number of substances. As regards Avogadro's number (the number N of molecules per gm.-mol.) the author finds $\sqrt[3]{N} = i\,Mr_i/M\epsilon_s$, where $i$ is a factor approximately equal to 0·39 for non-associated substances at low temperatures, $Mr_i$ the internal molecular heat of vaporisation, and $M\epsilon_s$ is the molecular capillary energy (not the free energy). If $N = 6{\cdot}2 \times 10^{23}$ (Planck, Rutherford and Geiger), then $i = 0{\cdot}38$; if $N = 6{\cdot}85 \times 10^{23}$ (Perrin), then $i = 0{\cdot}39$. For associated substances the $i$ values are theoretically and experimentally smaller. If the transition from liquid to vapour were discontinuous, $i$ should be about 0·5; thus the author's theory does not accept a completely discontinuous transition. H. B.

1375. *Gravitational Measurements in Sicily.* **A. Venturi.** (Accad. Lincei, Atti, 23. pp. 307–317, Oct. 29, 1914.)—The determination of gravitational anomalies in Sicily has been supplemented by measurements made at Memfi, in the Sciacca region; and at Sambuca-Zabut and Bisacquino, in the probable direction of the fracture which cuts through the island from Pantelleria to Termini. The anomalies found at these three stations were + 0·052, 0·064, and 0·020 cm. respectively. E. E. F.

1376. *Snowfall of the Eastern United States.* **C. F. Brooks.** (Monthly Weather Rev. 43. pp. 2-11, Jan., 1915.)—Snowfall in the Eastern United States is controlled generally by air temperature and moisture. On account of their low temperature and dampness the Lake region, Appalachians and North Atlantic coast get the heaviest snowfall, while the Ohio valley, the

South Atlantic and Gulf States are generally too warm for much snow. The snowfall in the north-west is moderate because of the winter dryness. Within these larger snowfall provinces the snowfall is locally modified by the topography and exposure to moist winds. Thus the Appalachians get heavier snows on their western than on their eastern slopes and the eastern shores of the Great Lakes get more snow than the western. Snow generally falls in connection with winter cyclones. The north-east wind is the wind of the great snowstorms because it is cold and damp. North-west winds, although cold, are generally too dry to bring much snow, except on a windward mountain slope where the effect of topography induces precipitation. R. C.

1377. *Foggy Days in Manchester.* **W. C. Jenkins.** (Manchester Lit. and Phil. Soc., Mem. 59, No. 5. pp. 1–4, April 30, 1915.)—An inquiry as to whether the number of foggy days in Manchester has increased or decreased in the past 10 years. A distinction is drawn between "fog days," that is days of surface fog, and "gloom days," days on which there was fog at a little distance above the surface but not actually on the ground. The figures for the 10 years are arranged in various ways, and it is found that taking the year as a whole the number of foggy and gloomy days combined has increased 30 % between the beginning and end of the period. The most marked part of this increase is in the number of days of gloom. J. S. Di.

1378. *Note on the Monthly Variation of Sunshine.* **W. W. H. Gee.** (Manchester Lit. and Phil. Soc., Mem. 59. No. 6. pp. 1–4, April 30, 1915.)—The author finds that taking mean monthly sunshine figures for a number of stations the max. percentage of possible sunshine occurs in May, with some traces of a secondary maximum in Aug. Diagrams are reproduced for several stations in different parts of the country, and this feature is well brought out. J. S. Di.

1379. *Monthly Weather Periodicity.* **V. Köppen.** (Meteorolog. Zeit. 32. pp. 180–185, April, 1915. Monthly Weather Rev. 43. pp. 179–181, April, 1915.)—In order to examine critically the popular belief that the moon exercises an influence on the weather, the five-day pressure variations over Europe are examined for 1875 to 1894, and it is found that in winter over Norway there occurred on the average during this time a maximum of pressure a few days after new moon, and a minimum of pressure a few days after full moon. The magnitude of the variation diminishes on all sides of Norway, until in Siberia the variation changes sign. Norwegian records prior to 1875 are wanting, consequently the corresponding variation is examined for Vienna from 1775 to 1914, when it is seen that although some particular kind of monthly variation repeats itself on the average for a considerable number of years (10 to 20), yet the type of variation undergoes slow variations, and is not by any means fixed. Moreover the variation of type appears to be capricious, and to follow no recognisable law. R. C.

1380. *Photometric Measurements of Daylight Illumination on a Horizontal Surface at Mount Weather, Va.* **H. H. Kimball.** (Monthly Weather Rev. 42. pp. 650–653, Dec., 1914.)—The observations discussed in the paper were taken during the period Sept. 17, 1913–Sept. 15, 1914, and were made both upon the total illumination on a horizontal surface from the sun and sky and on that part of it received from the sky alone, the sun's disc being artificially eclipsed. Tables are given showing the results from each set of measurements, and by combining the data in the two tables a measure of that part of the illumination which is derived directly from the sun is obtained. With a clear sky the total illumination at midday on a horizontal surface varies from 10,000 candle-ft. in June to 3600 in Jan. It is less than the direct solar illumination on a *normal* surface from Sept. to Feb. inclusive, but exceeds the latter from May to Aug. for a period of from 4 to 8 hours' duration in the middle of the day. (No observations were taken in March and April.) The illumination from a completely overcast sky may be half as great as the total illumination with a clear sky, and is frequently one-third as great. The ratio of skylight illumination to total illumination on a horizontal surface at noon on cloudless days in midsummer varies from ⅓ to ⅒, being greater in hazy weather than in clear. In midwinter it varies from ½ to ⅓. When the sky is clear the twilight illumination on a horizontal surface falls to 1 candle-ft. when the sun is about 6° below the horizon. It is found that radiation from an overcast sky is slightly richer in the proportion of light rays to heat rays than direct solar radiation, and radiation from a clear sky is markedly richer. J. S. Di.

1381. *Physical Conditions of the Accumulation of the Sun's Heat in the Salt Seas.* **M. Rózsa.** (Phys. Zeits. 16. pp. 108–111, March 15, 1915.)—The investigation of the accumulation of the sun's heat in some salt seas was first undertaken by Kalecsinszky, and the problem in general solved. In the present paper a report is given of the special physical conditions of the warming process, and some experimental researches in connection with this. It is found that a considerable accumulation of the sun's heat can only occur in those salt seas in which the upper layers increase in concentration in consequence of a more permanent diffusion process. A. E. G.

1382. *On the Accumulation of Warm Sea-water in Latitudes* 30° *N. and* 30° *S.* **J. W. Sandström.** (Ark. f. Mat. Astron. och Fysik, Stockholm. 9. 32, pp. 1–5, 1914.)—It is known that warm sea-water accumulates in lats. 30° N. and 30° S.; and that at the equator and in latitudes higher than 30° it is shallow in comparison with the depth at 30°. The suggested cause for this phenomenon depends upon the general air circulation, and the ocean currents induced by that circulation. At 30° N. and 30° S. there occur over the oceans the large permanent anticyclonic systems, and the winds belonging to these systems induce circulations in the oceans of which that in the N. hemisphere is clockwise, while that in the S. hemisphere is counter-clockwise. The effect of the earth's rotation upon a current tends to deflect it to the right of its path in the Northern, and to the left in the Southern hemisphere. At both latitudes, therefore, the water partaking in the "anticyclonic" circulation is gradually forced towards the centre of the circulation, the result being that the surrounding surface-water, heated by solar radiation, accumulates in these latitudes, causing the isothermal surface to sag there. The author illustrates the process by means of a small artificial anticyclone, produced by a suitable bellows, acting upon a rotating vessel of liquid. It is deduced that the amount of depression of the isothermal surfaces in those latitudes is a measure of the intensities of the superincumbent anticyclonic systems. R. C.

1383. *The Earthquake of Feb.* 18, 1911. **B. Galitzine.** (Comptes Rendus, 160. pp. 810–814, June 21, 1915.)—A rather violent earthquake occurred at Pamir on Feb. 18, 1911, which was registered at different seismological stations. The seismographs offered no outstanding features, and the occurrence would have been forgotten but for a coincidence having been recently noticed, that at the same date and time as the Pamir earthquake there took place at Sarez an enormous landslide which blocked up the valley of the river Mourgab and caused a lake to be formed. From the registered data the scene of the landslip is found to be identical with the epicentre of the earthquake. The author here discusses the problem as to whether the Sarez landslip was the consequence or the cause of the earthquake, from the point of view of energy liberated according as the earthquake or the landslip was the active agent. The conclusion arrived at is that the landslip was the cause of the earthquake and constitutes a unique example, since it affords a direct value of the total energy disengaged at the epicentre. H. H. Ho.

1384. *Recent Earthquakes at Santa Maura and Ithaca.* **D. Eginitis.** (Comptes Rendus, 160. pp. 774–777, June 14, 1915.)—The paper contains a very detailed account of the Grecian earthquakes of Nov. 28 and Nov. 27, 1914, and Jan. 27, 1915. The seismographic records show clearly that the centres of the three disturbances are different. The severity of the shocks did not extend far into the interior of Greece, but mainly affected the islands of Santa Maura and Ithaca. The origin of the earthquakes appeared to be submarine. H. H. Ho.

1385. *Avezzano Earthquake of Jan.* 13, 1915. **G. Grablovitz.** (Accad. Lincei, Atti, 24. pp. 597–604, April 19, 1915.)—Reports on the observations made at Ischia, and gives a map of isochronics round the epicentre at Conca del Fucino. E. E. F.

1386. *On the Reality of Singularities in a Seismograph.* **C. Mainka.** (Phys. Zeits. 16. pp. 241–247, July 15, 1915.)—This paper contains the results of an investigation into the singularities which seismographs exhibit, with the object of establishing their cause. They are found not to be of arbitrary occurrence or due to instrumental errors, since different forms of instrument record their definite existence. Four tables of data are given in support of the author's conclusions, who hopes by such dynamical means to determine the elastic constants of the materials of the earth's crust. H. H. Ho.

1387. *The Recent Activity of Kilauea and Mauna Loa, Hawii.* **S. Powers.** (Science, 42. pp. 147–154, July 30, 1915.)—The paper contains a detailed account of the activities of Kilauea and Mauna Loa during the past winter, which furnished the rather unusual spectacle of lava lakes within 22 miles of each other, but at a difference in altitude of practically 10,000 ft. The activity of these volcanoes in the immediate future is difficult to predict because of the scarcity of data prior to 1911. A general response of the lava to earth tides has been shown, that in Kilauea tending to rise at solstitial times and to sink at the equinoxes. H. H. Ho.

1388. *Inconvenience of Fourier's Solution in Trigonometric Series for calculating the Cooling of the Terrestrial Crust, and the Use of other Methods.* **J. Boussinesq.** (Comptes Rendus, 160. pp. 827–834, June 28, 1915.)—At the conclusion of the author's last note [see Abs. 1206 (1915)] on the cooling of the earth's crust, he has pointed out the lack of a method for calculating the final phase of the phenomenon with a sufficient degree of approximation. Fourier's solution in trigonometric series converges too slowly to be of convenient application. The author here discusses other methods by which this disadvantage may be remedied. H. H. Ho.

1389. *Spectrum and Temperature of the Solar Photosphere.* **A. Amerio.** (Accad. Lincei, Mem. 9. No. 9. pp. 328–388, 1914.)—This lengthy and exhaustive monograph gives a detailed account of the author's researches in this domain. The object of the investigation is set forth and the spectrobolometric arrangement employed is illustrated. It is impossible in a short abstract to cover the whole ground, but a few of the more important results may be referred to. The observations were made in 1908–1911 at 4 stations, namely Rome, Alagna, Col d'Olen, and Capanna Regina Margherita, the atmospheric absorption being calculated by imagining the atmosphere to be divided into 4 strata and assigning separate coefficients to each station, according to its elevation. From the total observations it is deduced that the radiation reaching the earth at the upper limit of the atmosphere, from the centre of the solar disc is 2·51 gm. cals. per cm.$^2$ per min. From this and from the data as to the energy distribution on the solar disc the solar constant 2·09 can be deduced. But the solar atmosphere has the effect of reducing the energy radiated by the photosphere in the ratio 150 : 100 ; so that the value of the solar constant if there were no solar atmosphere would be $2{\cdot}51 \times 1{\cdot}50 = 3{\cdot}76$, which is the photospheric solar constant $A_1$. The absorption of the solar atmosphere ranges from 33 % at angle 0° to 68·7 % at 90° ; the mean being 44·4 %. Applying Stefan's law, this gives a temperature of 6880° for the solar photosphere. The author's values for the solar atmospheric absorption for rays of different wave-length agree well with those of Abbott and Fowle ; but the values of *q* not so well. As regards the spectrum of the photosphere, this is found to be very similar to the spectrum of a black body having the same temperature. The apparent distribution of the total energy over the sun's disc varies with the altitude above sea-level. Finally, since a black body at 6900° will yield 5 % of its energy in the form of light, by assuming 20 candles to be obtainable per watt at 7000° we arrive at the figure 150,000 candles per cm.$^2$ for the luminous intensity of the photosphere ; that of the sun's disc is considerably lower, the mean intensity being about 67,000 candles per cm.$^2$ of surface. [See also Abs. 841 (1915).] L. H. W.

1390. *Systematic Motion of Stars from Radial Motions.* **A. S. Eddington** and **W. E. Hartley.** (Roy. Astron. Soc., M.N. 75. pp. 521–530, May, 1915.)—The investigation is based on the radial velocities published by Campbell from observations at the Lick Observatory, its object being to determine the position of the vertex and the average motion along the three axes of the velocity ellipsoid for the different spectral types. It is shown that there is a close agreement between the results obtained from proper motions and radial velocities. The mean result for the position of the vertex from 1086 stars of types A–M is R.A. = 94·6° ; Dec. = + 12·5°. There appears to be no evidence of a progressive change with spectral type of the position of the vertex, but there is a large deviation for stars of type G.

Star streaming is not shown for stars of type $A_0$, but is fully developed in the later stars of this type. These stars, however, exhibit a strong tendency to move parallel to the galactic plane. No trace of galactic influence is detected in the other types. C. P. B.

1391. *A Catalogue of Star Clusters shown on Franklin-Adams Chart Plates.* **P. J. Melotte.** (Roy. Astron. Soc., Mem. 60. Part 5. pp. 175–186, 1915.)

## LIGHT.

1392. *Flicker Photometer Attachment for the Lummer-Brodhun Photometer.* **E. F. Kingsbury.** (Frank. Inst., J. 180. pp. 215–223, Aug., 1915. Mech. Eng. 36. pp. 215–216, Sept. 17, 1915.)—In the earlier part of this article the author discusses some of the chief requirements to be complied with in a flicker photometer. One important point is that, with a size of field subtending about 2 degrees at the eye and an illumination of 25 candle-metres, flicker and equality-of-brightness photometers should give the same result. It is therefore useful to have an instrument which complies with this condition, and can be used either on the equality-of-brightness or flicker principle. The author describes an attachment to the Lummer-Brodhun photometer which converts this instrument to the flicker type, and is said to result in great sensitiveness. The observer looks at the field through a small 2-degree aperture. Between this aperture and the photometric field a rotating annular prism, driven by a small electric motor, is inserted, which brings before the eye in rapid succession the two sections of the field of the Lummer-Brodhun photometer. If the two sections are unequally bright a flicker ensues. A further refinement is the covering of the interior of the eyepiece with a matt white coating, illuminated by a small glow-lamp so as to be evenly bright all over. By means of a shutter the brightness can be varied to any extent, but should be approximately equal to that of the photometric field. The fact of the flicker aperture being observed with this surrounding luminous field appears to facilitate observations. J. S. D.

1393. *Accuracy of the Lens and Drop Method of measuring Refractive Index.* **H. R. Nettleton.** (Phys. Soc., Proc. 27. pp. 511–526, Aug., 1915.)—The lens and drop method of comparing refractive indices is a very accurate one when due regard is paid to the choice of lenses, and allowance made for the thickness. It is easily adapted to the optical bench and monochromatic light, and measurements may be made very quickly. The method is perhaps seen at its best when employing a suitable converging meniscus to measure refractive indices between 1·3 and 1·4. The method of measuring short radii of curvature in terms of the well-known refractive index of water is also frequently very useful and accurate just when other means are difficult or inaccurate. The lens and drop method may also be of service in finding the refractive index of the material of the lens. AUTHOR.

1394. *Index of Refraction of Gases.* **[Miss] J. T. Howell.** (Phys. Rev. 6. pp. 81–98, Aug., 1915.)—With interferometer plates nickeled by kathodic discharge, and using a Fabry and Perot interferometer in conjunction with a quartz spectrograph, the dispersion curve for air has been extended to λ2652, and those of hydrogen, oxygen, and $CO_2$ to λ2753. From the values found for the indices of refraction the dispersion formulæ of these gases were calculated by the method of least squares. For air the formula obtained is $\mu - 1 = 0{\cdot}00028817 + 11{\cdot}88 \times 10^{-15}/\lambda^2 + 4{\cdot}6 \times 10^{-24}/\lambda^4$, which differs very little from the formula of Kayser and Runge. The Sellmeier formula obtained is $\mu^2 - 1 = 5{\cdot}7 \times 10^{-4}\lambda^2/(\lambda^2 - 0{\cdot}6455 \times 10^{-10}) - 8{\cdot}067 \times 10^{-5}\lambda^2/(\lambda^2 - 0{\cdot}10116 \times 10^{-6})$. No Sellmeier formula could be calculated for hydrogen, as there is no absorption band near enough to the region observed. The Cauchy formula found is $\mu - 1 = 0{\cdot}00018876 + 0{\cdot}8 \times 10^{-14}/\lambda^2 + 1{\cdot}86 \times 10^{-24}/\lambda^4$. From the dispersion curve for hydrogen it is possible to calculate the ratio $e/E$, where $e$ is the charge on the dispersion electron and E the charge on the hydrogen ion. The mean value here obtained for the ratio is 0·94, which is consistent with the assumption that the hydrogen atom consists of a single electron and a nucleus carrying one positive charge. The oxygen dispersion curve rises so steeply in the ultra-violet that it was impossible to find constants in the Cauchy equation to fit the short-wave end of the curve. The following equation fits the curve in the region of longer waves:—

$$\mu - 1 = 0{\cdot}0002674 + 1{\cdot}2 \times 10^{-14}/\lambda^2 + 1{\cdot}06 \times 10^{-28}/\lambda^4.$$

No satisfactory Sellmeier formula could be derived; it is probable that the dispersion is influenced by too many absorption bands to be adequately represented by a formula of two terms. The dispersion curve for $CO_2$ is very flat in the region investigated, so that only the Cauchy formula was calculated. The formula found is $\mu - 1 = 0{\cdot}0004375 + 2{\cdot}58 \times 10^{-14}/\lambda^2 + 2{\cdot}3 \times 10^{-24}/\lambda^4$. The method employed in this work is found capable of very great accuracy for a small range of pressure-change. Preliminary tests with large changes of pressure give indications of success in this direction, although the large shift in interference bands may make it necessary to confine the work to the visible spectrum, where the whole number of bands going by can be counted.

A. W.

**1395.** *Electric Double Refraction in Liquids.* **H. E. McComb.** (Phys. Rev. 6. pp. 180–188, Sept., 1915.)—The velocity of light, vibrating in different planes in dielectric media subjected to electric strain, was first investigated by Kerr in 1894. After experimenting with a number of liquids he concluded that the velocity of the component vibration polarised perpendicular to the lines of force was changed. Later, Aeckerlein investigated the above effect in nitrobenzol and nitrotoluol. He found that in the former the perpendicular component is accelerated and the parallel component retarded, the ratio being about 2 : 1.

In the present investigation an attempt has been made to measure accurately the effect on each component. The method involves the measurement of the shift of the bands, using a Michelson interferometer arrangement. With *nitrobenzol* it is found that the component vibrating parallel to the lines of force is retarded and the perpendicular component accelerated, the ratio being 0·58. With *chloroform* both components are accelerated, the component vibrating parallel to the lines of force being the larger. With *carbon bisulphide* only the component vibrating parallel to the lines of force is affected—this component is retarded.

A. B. W.

**1396.** *Reflection from a Moving Mirror.* **W. G. Brown.** (Phil. Mag. 30. pp. 282–284, Aug., 1915.)—With regard to the question of alteration of amplitude by the Doppler-effect, raised by E. Edser (Ibid. 28. p. 508, Oct., 1914), the author here points out that the relation between the kinematics and electromagnetics of the problem is very clearly brought out by the Faraday tube theory of radiation. In this theory a tube of force lying along the direction of the ray is supposed to transmit transverse vibrations like an elastic string. The displacement of the tube from its equilibrium position alters the direction of electric intensity. If it is assumed that the magnitude of the component parallel to the ray is unaltered, then the transverse component of electric force will be equal to this unaltered intensity multiplied by the tangent of the angle between the tube and the ray. Thus, if $r$ measures distance along the ray, $z$ is the transverse displacement, and R and E are the $r$- and $z$-components of electric intensity, $E = R\partial z/\partial r$. The magnetic force is the product of the velocity of the tube, which is perpendicular to the ray, and the electric intensity perpendicular to that velocity, divided by $c^2$, so that $H = R/c^2 . \partial z/\partial t = R/c . \partial z/\partial r = E/c$. For waves obliquely reflected by a moving mirror, the following result is then obtained—

$$H_0'/H_0 = E_0'/E_0 = -\frac{m'}{m} = -\frac{\sin\theta}{\sin\theta'} = \frac{c + v\cos\theta}{c - v\cos\theta'}.$$

This result is independent of the plane of polarisation, and is in complete agreement with those of J. Larmor (Phil. Mag. 28. p. 705, Nov., 1914) and of E. Edser.

The assumption that the electric intensity along the ray is constant, and is not altered by reflection, is essential to the argument here given. E. H. B.

1397. *Law of Reflection of Gas Molecules.* **R. W. Wood.** (Phil. Mag. 30. pp. 300–304, Aug., 1915.)—Various phenomena connected with the flow of gases have led to the assumption that the gas molecule, on collision with a solid wall, is reflected at an angle which is quite independent of the angle of incidence, and that the number reflected in any given direction is proportional to the cosine of the angle which this direction makes with the normal to the surface. But no direct experimental evidence for it has apparently been obtained previously. The present paper describes experiments with mercury-vapour which appear to show that the cosine law is approximately followed. E. H. B.

1398. *Calculation of "Thin" Objectives.* **T. Smith.** (Phys. Soc., Proc. 27. pp. 485–500, Aug., 1915. From the National Physical Laboratory.)—Lens systems which are symmetrical about an axis have in general 6 degrees of freedom for first order aberrations. Thin systems have only 3 degrees of freedom, and in consequence of the limited range of glasses only 2 degrees of freedom are practically available. In achromatic combinations of two lenses these two degrees of freedom are controlled by the general shape as distinct from the total power of each lens. In general, when two given conditions are satisfied the curvatures of the inner surfaces are not equal, so that a cemented combination of two lenses is not possible. Owing to the increased light-transmitting powers it is often necessary to have only two glass air surfaces, and thus more than two component lenses are necessary. The effect of bending any thin system as a whole by increasing the curvature of each surface by the same amount is investigated, and it is shown that with two given kinds of glass a triple cemented lens can be formed satisfying two arbitrary aberration conditions. The problem reduces to the solution of quadratic equations, and in general there are four solutions. Illustrations are given of astronomical objectives of both double uncemented and triple cemented forms, and the glasses are determined for which a doublet can be cemented. AUTHOR.

1399. *On Tracing Rays through an Optical System.* **T. Smith.** (Phys. Soc., Proc. 27. pp. 502–509, Aug., 1915. From the National Physical Laboratory.)—Trigonometrical formulæ have been used for tracing rays not lying entirely in one plane through optical systems, as these can readily be arranged in a form suitable for logarithmic calculation. When a calculating machine is available such computations can be carried out more expeditiously by using algebraic formulæ given in the paper; in form these exactly correspond with the expressions for paraxial rays, and a comparison of the numerical result appears likely to suggest what alterations should be made when a general ray does not behave as desired. It is pointed out that if the two points in which a general ray meets an axial plane are defined as conjugate points, all pairs of conjugate points on a ray are connected by the same relations as hold for object and image points for paraxial rays, and the theory for paraxial rays can be extended to rays in general by placing a suitable interpretation on magnification, etc. The definition of conjugate points can be extended to include rays lying in axial planes, in which case the one point marks the intersection of the ray with the radial focal line formed by rays passing through its conjugate. AUTHOR.

1400. *Relation between Minimum Dispersion and Minimum Deviation in a Prism.* **H. Opitz.** (Deutsch. Phys. Gesell., Verh. 17. 18. pp. 240–249, July 15, 1915.)—Investigates mathematically the possibility of making a prism for which the angles of minimum dispersion and minimum deviation shall be the same. It is found that such a prism would have its refracting angle zero, and that the smaller the refracting angle the nearer does it fulfil the required condition. J. W. T. W.

1401. *Optical Properties of Diffusing Media.* I.–VI. (Am. Illum. Eng. Soc., Trans. 10. pp. 858–402, 1915.)—A series of reports dealing with the classification of diffusion and the general properties of diffusing materials, the methods of measurement and the geometrical theory of diffusion. Part III. deals with papers and inks, Part IV. with photographic papers, Part V. with window envelopes (containing a transparent portion), while Part VI. discusses the optical properties of walls, woodwork ceilings, and furniture as dependent upon material, finish, and covering. Much useful information, unobtainable elsewhere, is given in these reports, which should be referred to in the original. L. H. W.

1402. *Electron Theory of the Optical Properties of Metals.* II. **G. H. Livens.** (Phil. Mag. 30. pp. 434–445, Sept., 1915.)—A continuation of the theoretical investigation dealt with in Abs. 685 (1915).

1403. *Experiment on Sunset Colours.* **F. W. Jordan.** (Nature, 95. pp. 590–591, July 29, 1915.)—The purity of colour in a diffraction halo depends essentially on the size of the condensed droplets. The author describes a simple experiment in which the motion and distribution of different-sized water droplets in a cloud are partially controlled. The colours obtained on illuminating the cloud with sunlight are comparable with those of soap films and present the features of sunset colours. It is concluded that some of the brilliancy and extensiveness of sunset colours is due to a quiescent state or regular motion of the clouds or mist at sunset and also to a distribution into layers of droplets of nearly uniform size. T. H.

1404. *Absorption and Dispersion of Light in Dye Solutions.* **B. J. van der Plaats.** (Ann. d. Physik, 47. 4. pp. 429–462, July 8, 1915.)—An experimental investigation of the relationship between absorption and dispersion in dye solutions of various concentrations and a comparison of the results with the formulæ of modern theories. The author first surveys these various theories and describes the apparatus and methods of observation very fully. The results obtained would seem to conform best to Kettereler's method of treatment, although they do not differ markedly from the dispersion curves calculated from the other theories. Refraction indices obtained by the interferential-refractometer method for concentrated solutions agreed with theory to the third decimal place. Beer's law was substantiated so long as no fluorescence occurred. When, however, fluorescence was present, as Söderborg also has noticed, the absorption curve exhibits a slight elevation over the theoretical curve. The dyes investigated comprised erythrosin, crystal poppy (an azo-dye from α-naphthylamine β-naphthol-disulphonic acid 2, 6, 8), crystal violet and rose bengal (sodium tetraiododichlor fluorescein). C. S. G.

1405. *Relation between Infra-red and Ultra-violet Absorption; Variation in Absorption with Concentration.* **E. C. C. Baly and F. G. Tryhorn.** (Chem. Soc., J. 107. pp. 1121–1132, July, 1915.)—Further evidence is obtained in substantiation of Baly's theory of chemical reaction and reactivity. This theory [see Abs. 1258 (1914)] is based upon the unlocking in stages by light or solvent action of the closed and condensed electromagnetic force-fields which surround molecules. A simple application of the energy-quantum theory has led to a connection between the frequencies of infra-red and ultra-violet bands, and this connection is now shown to hold good in the case of benzaldehyde, salicylaldehyde, and pyridine. The effect of various solvents and of concentration has been carefully studied. The mass-action law does not hold good, but the absorptive power increases to a maximum on constant dilution. If K be the max. absorptive power and $k$ that at any concentration the following empirical relationship has been deduced and found to agree well with the observed values, $k/K = 1 - e^{-\alpha V^{1/n}}$. Here $\alpha$ is a solvent constant, $n$ a number depending on the number of entities into which the molecules are reversibly resolved, and V the volume in litres containing 1 gm.-mol. of the substance. For aniline in $CO_2$-free alcohol $n$ has a value 2/3.

The position of a band on solution shifts at first redwards until a minimum value of the central frequency is obtained. The concentration at which this occurs depends upon the solvation. Further dilution causes a progressive shift of the centre of the band towards shorter wave-lengths, until at great dilution a constant max. frequency is reached which is the same as that for the gaseous state. This shifting on dilution is due to the shifting of the fundamental infra-red frequency caused by the solvent. C. S. G.

1406. *Arc and Spark Spectra of Nickel under Pressure.* **W. G. Duffield.** (Phil. Mag. 30. pp. 385–394, Sept., 1915.)—In this paper the author makes a comparison between the results obtained by Bilham [Abs. 1988 (1914)] for the spark spectrum of Ni under 5 and 10 atmos. pressure, and the results of research upon the arc spectrum of the same metal when subjected to pressure [Abs. 852 (1915)]. Adopting the classification given by Bilham it is seen (1) that the spark displacements per atmo. of lines reversed both symmetrically and unsymmetrically under 10 atmos. pressure are smaller than those observed in the arc under the same pressure. For 14 lines the ratio of spark to arc displacements is 1·9 to 4·0. (2) The spark displacements per atmo. of lines which are unreversed, whether slightly broadened or greatly broadened towards the red under 10 atmos. pressure, do not differ appreciably from those observed in the arc under the same pressure. For six slightly broadened lines the ratio of spark to arc displacements is 4·8 to 5·0. For seven lines greatly broadened to the red, the ratio of spark to arc displacements is 9·7 to 11·6. (3) The displacements of reversed lines in the spark under a pressure of 10 atmos. are in good agreement with the arc readings derived from higher pressures. (4) Duffield inclines to the view that the differences between the arc and spark displacements (which are only pronounced in the case of reversed lines) are due to the differences in the positions of the absorption lines upon bright lines whose displacements are nearly, if not quite, the same, whether produced in the spark or the arc discharge. These conclusions would show that the spark and arc changes of wave-length under pressure are approximately equal for those lines which remain bright, and also for the emission-centres of lines whose vibrations are subject to absorption by the outer layers of the arc or spark. It appears to be the condition of the vapour as regards its pressure or density, rather than the means whereby it is excited, which in the main determines the displacements of the lines. Any effect due to length of arc, self-induction, or capacity appears to be superposed on this general effect, and is probably of a smaller order of magnitude. A number of additional points of interest in the comparison of the arc and spark spectra are given, and the paper concludes with some remarks on the influence of density and temperature gradients upon the displacement of spectrum lines. The difference in the displacements of the reversed parts of lines in the arc and the spark (which occasions an increased dissymmetry in the latter) is due to the fact that the density and temperature gradients are different in the two types of discharge. The author considers that these gradients affect the positions of the bright lines also, to a smaller extent, but for two reasons their influence is greater upon reversals. A. W.

1407. *Magnetic Spectrum of Oxygen Canal-rays.* **T. Retschinsky.** (Ann. d. Physik, 47. 4. pp. 525–562, July 8, 1915.)—An elaborate investigation of the oxygen canal-ray magnetic spectrum was made, using Wien's method [Abs. 961 (1910)]. The principal results obtained were the following:—The effects on the energy distribution due to discharge potential, current strength, pressure and sign of the charge were investigated. The energy curves obtained show several maxima. By employing crossed electric and magnetic fields a photographic method showed three different groups of particles in the canal-rays: (*a*) singly-charged molecules, (*b*) singly-charged atoms with velocities $\sqrt{2}$ times greater than for the molecules, (*c*) singly-charged atoms with velocities the same as for the molecules. Positive and negative particles have different energy distributions for the three groups of particles. It was found that the number of slow-moving atoms is greater than that of the faster ones and of the molecules. The velocity of the particles increases proportionally with the square root of the discharge potential. The energy of the slow positive atoms is weakened by rise of pressure in the observation chamber, and by lowering the discharge potential, relatively more than the energy of the faster atoms. A. W.

1408. *Ionisation Potentials, and the Single- and Many-lined Spectra of Hg, Cd, and Zn.* **J. C. McLennan** and **J. P. Henderson.** (Roy. Soc., Proc. 91. pp. 485–491, Aug. 2, 1915.)—Franck and Hertz have shown that the minimum energy required to ionise an atom of mercury is that acquired by an electron in passing through a fall of potential of 4·9 volts. They have also shown that when heated Hg-vapour is traversed by electrons possessing energy slightly above this amount the vapour is stimulated to the emission of the single spectral line λ2536·72. This result constitutes a new and most interesting application of the quantum theory, for in the relation $Ve = h\nu$, where $h = 6{\cdot}6 \times 10^{-27}$ erg sec., 4·9 volts is the potential-fall which corresponds to the frequency $\nu$ of the line λ2536·72. If this relation be applicable generally to all elements, it follows that if the vapour of an element can be shown to be capable of exhibiting a single-line spectrum, the frequency of this single spectral line may be used to deduce the minimum amount of energy required to ionise the atoms of that element. It has been found, as a result of the present investigation, that a spectrum consisting of a single line is obtainable for mercury, for zinc, and for cadmium. The wave-lengths of these lines are for Hg λ2536·72, for Zn λ3075·99, and for Cd λ3260·17. The minimum ionisation potentials are respectively 4·9 volts, 3·74 volts, and 3·96 volts. Some considerations are discussed which support Thomson's theory of the two types of ionisation of atoms of Hg, and others which suggest that the theory is applicable as well to the ionisation of atoms of Zn and Cd. The minimum arcing p.d.'s which will bring out the many-lined spectra of Hg, Zn, and Cd vapours were found to be 12·5 volts, 11·8 volts, and 15·3 volts respectively. These voltages are also probably the minimum ionisation potentials of the second type for the atoms of these three elements. Considerations are presented which suggest the possibility of analysing the spectrum of an element in such a way as to enable us to correlate different portions of the spectrum with disturbances in definite portions of the atomic structure of the element.

A. W.

1409. *Effect of Electric and Magnetic Fields on the Emission Lines of Solids.* **C. E. Mendenhall** and **R. W. Wood.** (Phil. Mag. 30. pp. 316-320, Aug., 1915.)—Paschen [Abs. 1534 (1914)] failed to detect any electric decomposition of the Hg 2536·7 line excited by resonance according to Wood's method [Abs. 968 (1913)]. This negative result raises the question which started the present work, namely, Is the absence of any influence of an external electric field due in this case to the nature of the vibrating system giving this line, as compared with the system giving other mercury lines for which the effect has been demonstrated, or is it due to the different method of excitation? For, with this exception, all sources so far examined for the Stark-effect have been excited by canal-ray bombardment, and it seemed possible that this mode of excitation might be a necessary, though not a sufficient, condition for obtaining the effect. It was therefore proposed to look for the Stark-effect in solids, both with fluorescent emission lines and with absorption lines, in the hope of finding an inverse effect. As regards the Stark-effect, the results have all been negative. A description is given of the conditions under which these negative results were obtained. The observations were carried out at liquid-air temperatures wherever possible, because of the greater sharpness of the lines. The lines examined were the following: A strong sharp fluorescent line λ5736 emitted by a specimen of Weardale fluorite. No change was observed with a field of 50,000 volts/cm., and no trace of broadening or splitting could be detected with a magnetic field of 22,000 gauss. No change could be detected with the ruby fluorescent lines λ6918, λ6932, with a field of 45,000 volts/cm. In the case of this pair of lines, in addition to the narrowing of the lines by the low temperature there was a shift of 12 Å. units towards the violet somewhat greater than that noted by Du Bois and Elias. At −180°

sixteen other lines appear on the side of longer wave-lengths, and the behaviour of these lines in a magnetic field is very interesting. The very bright lines already mentioned split up into unsymmetrical quadruplets. The centre of the middle pair of lines in each group remains fixed, but each group is unsymmetrical. The distance from the centre of the middle pair to the long-wave outer components is 0·25 Å. unit more than the distance to the short-wave components. The total separation of the outer components, with a field of 22,000 gauss, is 2·5 Å. units. The doublet λ6988·5–6990·2 behaves very curiously. As the field increases in strength this doublet widens slightly and becomes fuzzy, then narrows down into a single line, located at the centre of the initial doublet. Of the other lines some appear to be uninfluenced by the field and others disappear or become much blurred. Careful tests with sunlight for excitation showed that the strong red emission ruby lines are excited by light of their own wave-length. Comparing the fluorite and ruby lines, we have one showing no corresponding absorption, no synchronous resonance, no Zeeman and no Stark effects; this line may not be a normal mode; the other shows absorption, resonance radiation, and Zeeman-effect, but no Stark-effect, and apparently is a normal mode. From among the substances known to have fine visible absorption lines the following were selected for experiment: monazite, praseodymium sulphate, neodymium sulphate, neodymium nitrate, uranyl nitrate. Negative results were obtained in all cases, fields up to 60,000 volts/cm. being employed.

A. W.

1410. *Stark-effect and Atomic Structure.* **G. S. Fulcher.** (Astrophys. J. 41. pp. 359–372, June, 1915.)—A critique of certain recent work. The main experimental results are first summarised. A concise account is given of the facts discovered with regard to the lines of H, He, and Li, both in the case of observation perpendicular to the field (transverse effect) and in observation along the field (longitudinal effect). Some results are also given for Al, C, Ca, Hg, Mg, Na, and Th. The Wien magnetic effect is then briefly noted, as is also the combined Stark and Zeeman effects as investigated by Croze, Stark, and Garbasso. Details are then given regarding the hydrogen components, particular attention being paid to the fine analysis obtained by Stark with a specially designed spectrograph combining considerable dispersion with great light-gathering power. The number of components observed with this instrument varied from 18 to 28 for different H lines. Some regularities in the H components are immediately evident. (i) The shift for the outer components (P1*a*) increases regularly with the term-number. Voigt suggested the formula $\Delta n/n\mathrm{E} = \mathrm{A}(m+1)^2 \ldots (1)$; and the formula $\Delta n/n\mathrm{E} = \mathrm{B}m(m+2) \ldots (2)$ also fits the observations quite closely. (ii) The difference between the shifts of successive components (P1*a*, P2*a*, P3*a*, etc.) is approximately constant for each line, increases regularly from line to line with the term-number, and is roughly equal to P1*a* divided by $(m+2)$. We have then, apparently, $(m+2)$ P*a*-components, spaced regularly at a distance of $0{\cdot}213 \times 10^{-8}$ m. apart. So formula (2) may be generalised to include all the P*a*-components to

$$(\mathrm{P}a\text{-components})\ \Delta n/n\mathrm{E} = 2{\cdot}13 \times 10^{-9}[m(m+2) - m(p-1)] \ldots (3),$$

where $p$ is the number of the component and varies from 1 to $(m+3)$. (iii) Further investigation discloses similar regularities throughout. The positions of the components may all be represented within the apparently rather large experimental uncertainty, by certain equations (which are given) similar in general form to equation (3) above. Alternative equations are given for the P*a*, P*b*, S*a*, and S*b* components, and the present data available are not sufficiently accurate to decide which of each pair of equations better represents the facts. An accurate investigation of the electric resolution of $H\alpha$ and $H\epsilon$ would be interesting to determine whether the new data will fit these equations or not. He lines have also been studied carefully by Stark, but the results of the fine analysis have not yet been published.

The fact that it is the so-called diffuse series of H, He, and Li which show the Stark-effect most markedly points to a relation between broadening and the newly discovered effect. Wendt has found that in any series of lines the broadening increases with the term-number in the same manner as the Stark-effect. Stark also points out that the broadening is unsymmetrical in the case of those He and Li lines which show an unsymmetrical Stark-effect. These facts strongly suggest that broadening is due to the effect of the electric fields of atoms neighbouring on those emitting the light. But this is probably not a complete explanation. Stark also tries to connect the pressure-shift with the asymmetry observed in the electric resolution of some lines. This hypothesis is less firmly grounded than the preceding one, but should nevertheless prove stimulating to research.

As to the relation of the Stark-effect to atomic structure, the importance of the effect lies in the fact that this relation is so intimate. Without a more or less definite hypothesis as to atomic structure, it cannot be understood at all. Its details are new facts to be explained, new and most important criteria for judging proposed atomic models; but the results are also directly suggestive. These suggestions are as follows: (1) *Asymmetry of intensity in the case of a moving source.*—Stark interprets this result as meaning that the electrons emitting the more intense component are on the forward end of the moving atom and emit more light as a result of collision with gas molecules than do electrons at the back end of the atom. If a train of waves is emitted by each electron, this involves the assumption that the position of the active electrons with respect to a plane perpendicular to the velocity of the canal rays is unchanged during the emission of any one component; that is, they either vibrate about fixed positions of equilibrium or they rotate in planes perpendicular to the velocity of the atom. (2) *Croze's results and the Wien experiments.*—The velocity of the electrons affected by the magnetic field consists of two parts, that due to the motion of the atom as a whole and its velocity with respect to the atom. The latter is undirected with respect to the magnetic field. Stark argues from the fact that Croze obtained distinctly separated components (as did Garbasso also) that the speed of the electrons inside a hydrogen atom cannot exceed $10^6$ cm. per sec. Further and more accurate observations on the combined Zeeman-Stark effect will prove most important if they lead to an accurate determination of this internal electronic speed. (3) *The number of hydrogen components.*—Stark is inclined to overemphasise the complexity of the analysis effected by an electric field. Yet, though the components are all probably quite simply related, their number and sharpness indicate that each hydrogen line may be emitted by an electron under more than a dozen distinct sets of circumstances—distinct at least in that they are differently affected by an electric field. Stark suggests a ring of electrons, each emitting the same line when the electric field is zero, each equally affected by a magnetic field, but each differently affected by an electric field. The sharpness of the components necessitates the assumption that the ring is fixed in orientation and that the emission of light is due to the vibration of the electrons about a position of equilibrium. But since the components are not independent, it does not seem that they each do demand a separate electron as their source any more than the numerous band lines of nitrogen require an equal number of electrons in the nitrogen molecule. Yet the hydrogen atom must be a much more complex affair than any of the suggested atomic models.

Other important clues to atomic structure are noted, and in connection with the Doppler-effect for canal-rays it is pointed out that Stark's results for helium would lead to the conclusion that the nucleus must contain the electrons which emit the series lines. While these clues are not at all conclusive, they suggest quite definitely the following vague picture of a hydrogen atom: A neutral hydrogen atom consists of a small nucleus with a charge, $+e$, about which one electron revolves in dynamic equilibrium. Such a neutral atom cannot emit the Balmer series; it must first lose an electron by collision or otherwise. The Balmer series is emitted by electrons in the nucleus, vibrating about positions of static rather than dynamic equilibrium. Of the forces holding the parts of the nucleus together we know nothing except that apparently, according to Voigt, the forces involved are not isotropic, though they may be quasi-elastic. A swift electronic ray passing near the nucleus causes the emission of characteristic X-radiation; while the shock of ionisation results in the emission of light whose frequency may be affected by external magnetic and electric fields. Whether or not the nucleus contains magnetons we have no evidence on which to base an opinion. When two atoms combine to form a molecule the mutual influence of the nuclear fields changes the frequencies of vibration, so that the spectrum emitted is quite different. In the case of Bohr's atom, he does apparently succeed in relating the constant of the Balmer series to the Planck constant. But his assumption that the series lines are emitted by the single rotating electron of the hydrogen neutral atom is directly contrary to Stark's experimental result, which is one of the most certain clues we have. A. W.

1411. *Bohr's Theory of Series Spectra of Hydrogen and Helium.* **E. Riecke.** (Phys. Zeits. 16. pp. 222–227, June 15, 1915.)—A mathematical *résumé* of the whole subject. E. H. B.

1412. *Influence of the Hardness of an X-ray Tube on the Interference Patterns of Crystals.* **W. Friedrich.** (Ann. d. Physik, 44. 8. pp. 1169–1182, Aug. 4, 1914.)—Contains an account of a more extended investigation of the question whether the intensity of the X-rays changes with the degree of hardness of the tube [see Abs. 678 (1914)]. The intensities were measured by determining the blackening by means of a Hartmann microphotometer, and the same tube was employed for both the hard and soft conditions. For zinc blende the previous results were confirmed. Diamond is here also investigated. In this case the influence of hardness shows itself in the same sense as would be expected from the results with zinc blende. Values of $2a/\lambda$ are smaller as a whole, and this is attributed to the great difference in the grating constants, namely, $5{\cdot}43 \times 10^{-8}$ cm. for zinc blende and only $3{\cdot}52 \times 10^{-8}$ cm. for diamond. It is, however, pointed out that it was not possible to obtain a good diamond crystal which was capable of furnishing photometrable interference spots, and for this and other reasons Bragg's method of measuring the spectral intensity distribution is less open to question than the method here described. L. H. W.

1413. *Theory of Absorption, Fluorescence, and Phosphorescence.* **E. C. C. Baly.** (Astrophys. J. 42. pp. 4–71, July, 1915.)—A long paper giving a complete survey of the author's theory of absorption and luminescence, which has appeared in partial form in various recent publications. The theory is conveniently divided into two parts, one dealing with absorption and luminescence as a function of the electromagnetic force-fields of atoms and molecules, and the other with the relation between the phenomena of the ultra-violet, visible and infra-red spectral regions on the basis of the energy quantum theory.

In the first part the author has applied to molecules the electromagnetic fields surrounding atoms, used by Humphreys to explain the Zeeman and the pressure-shift effects. These atomic fields are only free and independent in metastable molecules; normally they are condensed to form a molecular field with escape of energy. A molecule with entirely closed fields has no reactivity, but if max. condensation leaves an uncompensated residuum the molecule will possess residual affinity. Closed molecular fields can be opened by other molecules possessing residual affinity, and then an equilibrium between opened-up and non-opened-up molecules ensues, on which the chemical reactivity depends. Light also acts as an opening agent and shifts the equilibrium to the reactive or opened-up side, whilst work is done on the system and the light is selectively absorbed.

In complex force-fields networks of potential gradients exist which are attacked and opened up in turn by suitable solvents, so that the process takes place by stages. Each stage is characterised by its selective absorption of definite wave-lengths, and thus represents a vibration period of the molecular system. The absorbed light-energy is emitted at some frequency characteristic of the system, usually in the infra-red, but in certain cases it may be emitted in the visible and ultra-violet regions, giving rise to fluorescence and phosphorescence. Experimental proof is furnished in three sets of observations: (1) the existence of intermediate phases in chemical reactions, which phases represent higher stages in the opening-up of the molecular force-fields, and which are recognisable by their power of absorbing light of longer wave-length; (2) the variation in absorptive power with progressive dilution in solutions; (3) the fact that the fluorescence emission of certain organic compounds in one solvent has the same wave-length as the light absorbed by the same compound in a second solvent.

In the second part it is shown that the frequencies of all absorption, fluorescence and phosphorescence bands of a substance are multiples of the frequency of an absorption band in the short-wave infra-red region. A constant frequency-difference exists between the centres of successive band groups whether absorption, fluorescence or phosphorescence, which is equal to the frequency of this short-wave infra-red band. In Sellmeyer's formula for the refractivities of gases a multiple of a measured infra-red band can be substituted for the frequency of the theoretical absorption band. The structure of absorption- and luminescence-band groups is partly due to the combination of the central frequency with the frequencies of the short-wave infra-red absorption bands according to the formula $C \pm v_x$, where C is the central frequency and $v_x$ the frequencies of the infra-red bands. Absorption, fluorescence, and phosphorescence in any region may be completely calculated from the molecular frequencies, which, according to Bjerrum, are given by the expression $nh/2\pi^2 I$, where $h$ is Planck's constant, I the moment of inertia, and $n = 1, 2, 3$, etc. Each complex molecule has at least two *basis constants*, $h/2\pi^2 I$, and successive multiples of these give rise to absorption bands in the long-wave infra-red region. Convergence frequencies of two or more series of basis constants or multiples of such convergence frequencies condition absorption bands in the short-wave infra-red, the visible and the ultra-violet regions. By combination of these convergence frequencies or their multiples with successive multiples of the basis constants, according to the formula C ± *n*K, where K is a basis constant, all the component lines of any band group may be calculated. The ultra-violet band of benzene illustrates this exceedingly well. Heads of sub-groups are due to the combination of the central frequency with those multiples of the basis constants which are sufficiently active to evidence themselves as absorption bands in the short-wave infra-red region. Finally, absorption bands in the infra-red and all the component lines of the ultra-violet absorption band groups of a compound of two radicals can be calculated from the basis constants of the two radicals. Thus the absorption lines of phenol and aniline are shown to be derived from the constants of benzene and water and benzene and ammonia respectively.

C. S. G.

**1414.** *Space-lattice of Calc-spar.* **A. Johnsen.** (Phys. Zeits. 15. pp. 712–715, July 15, 1914.)—Discusses the atomic structure of calc-spar as revealed by the X-ray spectrometer. It is concluded that each C-atom and three O-atoms belong to one another more closely, not only spacially but also physically, than the remaining atoms. The behaviour is thus, in brief, just as though the calc-spar consisted of Ca ions and $CO_3$ ions. L. H. W.

**1415.** *X-ray Spectra of some Metals.* **H. Rohmann.** (Phys. Zeits. 15. pp. 715–717, July 15, 1914.)—The author gives a series of reproduced photographs of the X-ray spectra of the metals Ni, Cu, Zn, Mo, Ag, Pt, Au, Th; the metals being used as antikathodes in a small X-ray bulb.—Thorium shows a remarkable behaviour when exposed to kathode rays. If after the bulb has been some time in use the antikathode is shifted a little so that the focus now falls on a new spot, the spot which previously was the focus lights up, under the influence of the weak radiation, with a very intense bluish fluorescence —much stronger than the focus itself. This effect continues for some time.

L. H. W.

**1416.** *Measurement of X-ray Energies.* **B. Winawer** and **St. Sachs.** (Phys. Zeits. 16. pp. 258–264, July 15, 1915.)—A description is given of a simple method of measuring the energy of X-rays. The principle of the method is as follows: The X-radiation is compared with the γ-radiation from radium, a thin-walled "air-electroscope" being employed for this purpose. From the ratio of the observed ionisation currents, the known absorption-coefficient of γ-rays in air [see Chadwick, Abs. 1200 (1912)], and the coefficient for X-rays (easily determined from observations of the absorption of X-rays in water or in liquid air), it is easy to obtain the "*true*" radium-equivalent of the X-radiation. The observations made with the "air-electroscope" can be used in the calculation of a reduction factor for any simple metal electroscope of the ordinary type. When such a factor has once been determined, it is then possible to use the ordinary electroscope for the direct comparison of the energies of γ-rays and X-rays.

The radium-equivalents of the X-rays thus determined are in good agreement with the calculated heating-effects. As a consequence of measurements of the above character, the authors suggest a *unit of energy to be used in X-ray measurements.* It is defined in the following way:—A beam of X-rays will have unit energy if, by its complete absorption in air, it produces the same number of ions as the γ-rays from 1 gm. of radium (B + C) would produce under similar conditions. A. B. W.

**1417.** *Maximum Frequency of X-rays from a Coolidge Tube for Different Voltages.* **E. Rutherford, J. Barnes,** and **H. Richardson.** (Phil. Mag. 30. pp. 339–360, Sept., 1915.)—The Coolidge tube, with tungsten antikathode, which was employed in these experiments was exhausted so perfectly that it maintained, with suitable precautions, 175,000 volts across its terminals without any obvious breakdown of the vacuum.

After describing the method and arrangement of the experiments an interesting description is given of the methods of measuring the voltage and the current. The absorption curves in Al of the X-radiation from the Coolidge tube have been examined over a wide range of constant voltages supplied by a Wimshurst machine. While the main radiation is complex, the "end" radiation is found to be absorbed experimentally. The absorption curves for different voltages obtained with an induction-coil are nearly the same as for the Wimshurst machine, and the penetrating power of the end radiation is nearly the same. The max. frequency of the "end" radiation for voltages between 13,000 and 175,000 volts has been deduced by examining its absorption in Al. The frequency and penetrating power reach a maximum value at 145,000 volts, and are not altered by increase of the voltage to 175,000. The shortest wave-length emitted by the Coolidge tube is $1{\cdot}71 \times 10^{-9}$ cm., or 0·17 Å.U. The absorption coefficient of this radiation in Al is 0·39 $(\text{cm.})^{-1}$; and in lead 23 $(\text{cm.})^{-1}$. The penetrating power of this radiation is about 3/10 of the penetrating γ-rays from RaC. The following table of results shows that the relation between the frequency and the voltage is expressed by the formula $h\nu = E - cE^2$, where E is the energy of the electron, $c$ a constant, and $h$ is Planck's fundamental constant. This relation holds up to 142,000 volts, where the radiation has its max. frequency:—

| Kilovolts. | Frequency calculated from relation $h\nu = E - cE^2$. | Observed Frequency. |
|---|---|---|
| 13·2 | $3{\cdot}07 \times 10^{18}$ | $2{\cdot}94 \times 10^{18}$ |
| 20 | 4·54 ,, | 4·41 ,, |
| 30 | 6·55 ,, | 6·44 ,, |
| 40 | 8·39 ,, | 8·34 ,, |
| 50 | 10·06 ,, | 10·1 ,, |
| 60 | 11·56 ,, | 11·6 ,, |
| 70 | 12·88 ,, | 13·0 ,, |
| 80 | 14·04 ,, | 14·1 ,, |
| 90 | 15·02 ,, | 15·3 ,, |
| 100 | 15·83 ,, | 16·0 ,, |
| 110 | 16·47 ,, | 16·5 ,, |
| 125 | 17·1 ,, | 16·9 ,, |
| 142·5 | 17·4 ,, | 17·4 ,, |

Evidence is given that the quantum theory is directly applicable for the excitation of waves of low frequency, but for higher frequencies requires a correcting factor, the value of which rapidly increases with the frequency. A simple and probable explanation of this is advanced.

A comparison is given of the radiation from a Coolidge tube with the γ-radiations emitted by RaB and RaC. A. B. W.

**1418.** *Efficiency of Production of X-rays from a Coolidge Tube.* **E. Rutherford** and **J. Barnes.** (Phil. Mag. 30. pp. 361–367, Sept., 1915.)—The question of the efficiency of the production of X-rays, *i.e.* the ratio of the energy of the generated X-rays to that of the exciting kathode rays, has been the subject of numerous investigations. Recently the question has been attacked under more definite conditions by R. T. Beatty [see Abs. 245 (1914)], who finally concluded that the efficiency of production of X-rays by matter in general was given by the following formula: X-ray energy/Kathode-ray energy $= 2{\cdot}54 \times 10^{-4} A\beta^2$, where A is the atomic weight of the radiator and $\beta$ the velocity of the kathode rays as a fraction of the velocity of light. [Beatty has since amended the above relation to Efficiency $= 0{\cdot}51 \times 10^{-4} A\beta^2$.] In the experiments with the Coolidge tube [for a description of which see preceding Abstract] the efficiency of production of the X-radiation for voltages 48,000, 64,000, and 96,000 has been examined. For such high voltages, the radiation is too penetrating for complete absorption in a reasonable length of air or other gas. To overcome this difficulty, measurements have been made of the ionisation due to a definite length of a beam of X-rays in air, and from this was deduced the absorption in air indirectly by determining the absorption curve of the radiation in *water*. It is shown that the absorption by 1 cm. thickness of water is equivalent to that by 8·2 m. of air at laboratory temperature. The intensity of the radiation was found to be directly proportional to the current through the bulb.

It will be seen from the following table that the efficiency is proportional to $\beta^2$ and is in fairly good accordance with Beatty's amended relation $E = 0{\cdot}51 \times 10^{-4} A\beta^2$.

| Voltage. | Ratio $i_1/i_2$. | Efficiency. | $\beta^2$. | Efficiency/$\beta^2$. |
|---|---|---|---|---|
| 48,000 | 0·86 | $0{\cdot}59 \times 10^{-3}$ | 0·165 | 3·6 |
| 64,000 | 1·44 | $0{\cdot}74 \times 10^{-3}$ | 0·211 | 3·5 |
| 96,000 | 3·01 | $1{\cdot}04 \times 10^{-3}$ | 0·292 | 3·6 |

Assuming the correctness of the data involved, the value $E = 7{\cdot}6 \times 10^{-5} A\beta^2$ is given as approaching the truth. From the low value of the efficiency at high voltages it is seen that, on the average, 1 electron only in 200 is efficient in producing radiation. A. B. W.

1419. *X-ray Wave-lengths.* **W. Duane** and **F. L. Hunt**. (Phys. Rev. 6, pp. 166–171, Aug., 1915. Abstract of paper read before the Am. Physical Soc., April, 1915.)—Using a Coolidge tube with a tungsten target, it is shown that a *constant* p.d. produces X-rays of a great variety of wave-lengths. Energy measurements were made for 6 different wave-lengths, corresponding to 6 different "glancing angles" respectively. From observations of the voltage applied to the tube, the ionisation current and the current passing through the tube, the authors calculate the value of "$h$," Planck's constant from the relation $V_0e = h\nu_0 = hc/\lambda_0$, where $e$ = electron charge, $c$ = velocity of light, and $V_0$ is the minimum voltage required to produce X-rays of wave-length $\lambda_0$. The average value $h$ determined in this way is $6{\cdot}39 \times 10^{-27}$, in close agreement with the value $6{\cdot}41 \times 10^{-27}$ given by Planck. The results thus give strong support in favour of the fundamental principle of the quantum hypothesis, for they show that the rays of frequency $\nu$ are not produced unless the energy available is equal to $h\nu$. It is also shown that the ratio of $\lambda_e$ to $\lambda_0$, where $\lambda_e$ is the effective wave-length of the whole radiation and $\lambda_0$ is as defined above, is about 1·50 at 40,000 volts and after the rays have passed through 3 mm. of Al. This ratio increases as the voltage increases, and consequently the effective frequency is not proportional to the voltage—it increases less rapidly. The wave-length $\lambda_m$, corresponding to maximum energy radiation, has not yet been measured accurately. A. B. W.

**1420.** *High-frequency Spectrum of Tungsten.* **J. Barnes.** (Phil. Mag. 30. pp. 368–370, Sept., 1915.)—The method used for obtaining and photographing the spectrum was the same as that employed by Moseley [Abs. 1249 (1914).] The following table contains the results obtained with a rock-salt crystal, 1·6 cm. thick, whose face was 8·5 × 1·9 cm.; the wave-lengths being calculated from the formula $\lambda = 2d \sin \theta$, $d$ being taken as $2{\cdot}814 \times 10^{-8}$ cm.:—

| Reflection Angle. | Wave-lengths × $10^8$ cm. | Intensity. |
|---|---|---|
| *15° 18′ | 1·477 | Strong |
| 13° 29′ | 1·312 | Weak |
| 13° 19′ | 1·296 | Strong |
| 13° 07′ | 1·277 | Weak |
| 12° 55′ | 1·258 | Strong |
| 11° 24′ | 1·118 | Strong |
| 11° 05′ | 1·082 | Weak |

* The only line on the spectrum of tungsten referred to by Moseley, which he designates the $\alpha$-line of the "L" series.

A. B. W.

**1421.** *Passage of α-Particles through Hydrogen.* II. **E. Marsden** and **W. C. Lantsberry.** (Phil. Mag. 30. pp. 240–248, Aug., 1915.)—The paper commences with a brief review of previous work on this subject by Marsden [see Abs. 1425 (1914)]. In the present work it is shown that H-particles are emitted from an $\alpha$-ray tube or a wire coated with RaC. From a determination of the number of these H-particles (measurements being made by a scintillation method) it is demonstrated that only a small fraction are accounted for by the presence of hydrogen gas in the active source (*i.e.* in the emanation tube, or occluded in the wire). The following figures were found for the number of H-particles per equivalent mgm. of radium element, observed in air at a distance of 8 cm. from the source. The area of the ZnS screen observed was 1·17 mm.$^2$:— RaC, 0·20 per min.; RaEm (+ A + C in $\alpha$-ray tube), 0·07 per min. The comparatively large number of H-particles emitted from RaC on nickel suggests that occluded hydrogen or water-vapour is not the cause. Hence there is strong evidence that H-particles are emitted from radio-active atoms themselves, although not with uniform velocity.

A. B. W.

**1422.** *Possible Connection between α-Ray Velocities and the Quantum Hypothesis.* **H. R. v. Traubenberg.** (Phys. Zeits. 16. pp. 264–265, July 15, 1915.)—Using the equations due to Bohr, $mv^2 1r = eE/r^2$ ... (1) and $mvr = h/2\pi$ ... (2), the author has shown previously how it is possible to calculate the velocities of $\beta$-rays emitted from radio-active substances. This process is now extended to the consideration of $\alpha$-ray velocities. Taking the particular case of RaC, the author gives the value of $v = 1{\cdot}63 \times 10^9$ cm./sec. as the calculated velocity of the $\alpha$-particles, whereas direct measurement of this velocity gives $v = 2{\cdot}06 \times 10^9$ cm./sec. Other $\alpha$-ray velocities are calculated in a similar manner. A. B. W.

**1423.** *Relation between α-Ray Activities and Ranges of Radium and its Short-lived Products.* **H. N. McCoy** and **E. D. Leman.** (Phys. Rev. 6.

pp. 184–191, Sept., 1915.)—In a recent paper [Abs. 179 (1915)] the authors have shown that the ratio between the α-ray activity of radio-actinium and that of its products is in good agreement with the value calculated from the equation $I = kR^{2/3}$, where I is the ionisation current in air due to a single α-particle, R the range of the α-particle, and $k$ is a constant for α-particles of all ranges. McCoy and Viol [Abs. 1966 (1913)] had previously shown that the relative α-activities in the Th series, as calculated from the same equation, are in good accord with experimental values. The authors now attempt to show that the relative activities of Ra and its short-lived products are also in good agreement with those calculated from the known ranges. The method consists in preparing a Ra-$BaSO_4$ film free from all of the subsequent products of Ra, and measuring its initial and final activities.

The results of this investigation are included in the following table:—

| Ratios Measured. | Found. | Calculated. |
|---|---|---|
| Thorium X and products to radio-thorium | 3·66 | 3·60 |
| Thorium $C_1$ and $C_2$ to radio-thorium | 1·54 | 1·56 |
| Actinium X and products to radio-actinium | 4·67 | 4·68 |
| Radium Emanation and products to radium | 4·11 | 4·09 |

In this table the values headed "Found" are the relative observed α-ray activities of the indicated substances. The calculated values were obtained by means of the equation $I = kR^{2/3}$, according to which the number of ions produced by an α-particle is proportional to the 2/3 power of its range.

A. B. W.

**1424.** *Excitation of γ-Rays by β-Rays.* **J. Szmidt.** (Phil. Mag. 30. pp. 220–224, Aug., 1915.)—It was shown by J. A. Cray [Abs. 1144 (1911)] that the β-rays from RaE falling on metallic radiators produce a certain amount of secondary γ-radiation. The penetrating power of this secondary radiation was found to vary widely, being as a rule softer the lower the atomic weight of the radiator. A similar result holds when kathode particles fall on the radiator, exciting its characteristic radiation [see Abs. 606 (1913)]. The experiments now described show that these secondary γ- and X-rays are identical, by comparing their absorption in Al. After a description of the apparatus and experimental methods the author gives the following interesting results:—

| Atomic Weight. | | Mass absorption coefficient μ/ρ in Al. | |
|---|---|---|---|
| | | for γ-rays. | for X-rays. |
| Iron | 55·8 | 91·8 cm.$^{-1}$ Al. | 88·5 cm.$^{-1}$ in Al. |
| Nickel | 61·3 | 58·8 | 59·1 |
| Copper | 63·6 | 46·8 | 47·7 |
| Zinc | 65·4 | 39·8 | 39·4 |
| Silver | 107·9 | 2·6 | 2·5 |
| Tin | 119·0 | 1·6 | 1·57 |

It is seen that there is a close resemblance between the radiations in the two cases. The difference in values is not greater than the experimental error.

A. B. W.

1425. *Relation between Uranium and Radium. VI. Life-period of Ionium.* **F. Soddy** and **A. F. R. Hitchins.** (Phil. Mag. 30. pp. 209–219, Aug., 1915.)—A clear growth of radium in a uranium solution, initially purified from Ra, was observed by Soddy in 1904 [Abs. 748 (1905)], but the extreme slowness of the growth suggested the existence of a long-lived intermediate parent of Ra, which was separated by Boltwood in 1907 and named ionium. The present series of experiments was started in 1905. Uranium preparations, purified extremely carefully so that neither Ra nor Io were initially present, have been examined for radium-content from time to time. From a large number of such measurements it is now possible to say that a definite growth of Io and Ra from Ur has been experimentally observed, and to fix the true period of ionium approximately. The growth of radium appears to be proceeding according to the square of the time, as theory requires if ionium is the only long-lived intermediate member of the series. The period of average life of Io calculated for experimental observations is about 100,000 years, assuming 2875 years as the period of Ra. The effect of any Io initially present in the preparations used would be to lengthen the period of ionium, but 100,000 years is probably not far from the actual period of average life. A. B. W.

1426. *X-ray Spectra of Cubic Crystals, especially of Iron Pyrites.* **P. P. Ewald** and **W. Friedrich.** (Ann. d. Physik, 44. 8. pp. 1183–1196, Aug. 4, 1914.)—This paper deals with the molecular structure of iron pyrites, hauerite, and sodium chlorate, and contains photographic reproductions of their interference figures. The views of G. Friedel [Abs. 674 (1914)] regarding the symmetry of the interference figures are confirmed. The structure of pyrites as put forward by Bragg is correct in the main, but there are inaccuracies in the values for the molecular separations. A method based upon the interference figure of pyrites is outlined for reducing this discrepancy and is applied to the case of hauerite, $MS_2$. L. H. W.

1427. *Photographic Spectro-photometry of X-rays.* **W. Friedrich** and **P. P. Koch.** (Ann. d. Physik, 45. 3. pp. 399–418, Sept. 15, 1914.)—The author gives an account of his attempts to develop a method of determining relative X-ray intensities by means other than the usual ionisation methods. A method making use of photographic photometry is worked out, and the results of the author's experiments lead him to give the following as the most satisfactory procedure :—After one has made certain, by means of a test, that the highest intensity to be measured gives a blackening that is still within the range of blackening obtainable with the tube photometer, a plate is exposed in the photometer, simultaneously and for the same length of time as for the measuring plate (the relative intensities of an image on which are to be measured) ; this first plate is the photometric plate with the intensity scale. The X-ray tube which is supplying the rays for the measuring plate is caused to play upon a sheet of some suitable material, which latter yields a secondary radiation of hardness somewhat less than that used for the exposure of the measuring plate ; the photometer being kept in rotation during the exposure. The measuring and photometric plates are then simultaneously developed, fixed, and washed. Measurement of the blackening can be made with any photometer or any suitable scale. In cases where a simultaneous photometric scale is not made, the relative intensities can be estimated within 10 per cent. by using a formula and some tables for use therewith which are given in the paper. L. H. W.

# HEAT.

**1428.** *Synthermal Regulator for maintaining an Adiabatic Condition in Calorimetry.* **T. W. Richards and G. D. Osgood.** (Am. Chem. Soc., J. 37. pp. 1718–1720, July, 1915.)—The object of this apparatus is the maintenance of identical, although variable, temperatures in two different vessels, such as the calorimeter and the surrounding bath used in adiabatic calorimetry. It consists of a pure hydrogen, differential thermometer, the two copper or silver cylinders of which are connected with a bulbed U-tube containing mercury and fitted with sealed-in, finely pointed wires of Pt + 8 % of Ir. In order to diminish sparking, a low e.m.f. is employed, and the current made and broken between the Pt and mercury is passed through a relay and thus governs a powerful current capable of either heating the second vessel directly or operating some mechanism for this purpose. The former of these methods is suitable for slow temperature-changes, but with rapid reactions better results are obtained by adding alkali to the second vessel or outer bath and using the strong current from the relay to turn on and off the flow of sulphuric acid into this vessel; for cooling reactions, ice-water could be used in place of the acid, the alkali being omitted. Efficient stirring is necessary in both vessels. Experiment shows that the temperatures of two vessels may be kept equal to within 0·03 deg. C. T. H. P.

**1429.** *Coefficient of Expansion of Sodium.* **E. A. Griffiths and Ezer Griffiths.** (Phys. Soc., Proc. 27. pp. 477–483, Aug., 1915.)—The difference in expansion of a volume of sodium and an equal volume of glass (or quartz) was measured by differential weighing under oil at various temperatures. A volume of about 250 cm.$^3$ of sodium was suspended from one arm of a short-beam balance and a weighed glass bulb of equal displacement from the other arm. The experiments show that sodium expands quite uniformly with the temperature up to its melting-point. The value 0·000226 was deduced for the coefficient of expansion. In changing from the solid to the liquid state, an increase of 2·57 % occurs in the volume. L. H. W.

**1430.** *Melting-point of Tungsten.* **I. Langmuir.** (Phys. Rev. 6. pp. 138–157, Aug., 1915.)—Observations on evacuated and on gas-filled tungsten lamps indicate that the intrinsic brilliancy of solid tungsten, at a temperature just below the melting-point, is about 7200 international candles per cm.$^2$ According to Rasch's equation [Abs. 2526 (1904)], with constants determined by Nernst [Abs. 1254 (1906)], and with an emissivity determined by v. Wartenberg, Coblentz and v. Pirani [see Abs. 883, 1225 (1910), and 1226 (1912)], this intrinsic brilliancy should correspond with a temperature of 3540° K. for the melting-point. Analysis of the sources of error of this method gives no reason to suspect an error greater than 50 degrees.

Two other methods for determining the melting-point of tungsten by means of a Holborn-Kurlbaum pyrometer have also been used. In the first of these, the black-body temperature of tungsten filaments heated to their melting-point is determined, while the emissivity is measured by observations on helically wound filaments. In the second method, an a.c. arc is passed between two tungsten electrodes placed close together in an atmosphere of nitrogen, the current being increased until the surfaces of both electrodes are molten. By measuring the intrinsic brilliancy of the molten surface, as well as that of the image of one electrode reflected in the other, the black-body temperature and the reflectivity can be measured simultaneously on the same surface. The first of these methods gave for solid tungsten an emissivity of 0·46 (for $\lambda = 0{\cdot}667\,\mu$) and an average melting-point of 3582° K. The second method gave as the emissivity of molten tungsten 0·425° (for $\lambda = 0{\cdot}667\,\mu$) and a melting-point of 3566° K.

From a consideration of the sources of error involved in the determination, it is concluded that the most probable value for the melting-point of tungsten is 3540° K ± 30°. T. H. P.

**1481.** *Thermal Conductivity of Selenium Crystals in Light and Darkness.* **L. P. Sieg.** (Phys. Rev. 6. pp. 213–218, Sept., 1915.)—The increase in the electrical conductivity of Se caused by the action of light, coupled with the well-known connection between the electric and the thermal conductivities of metals suggests that the thermal conductivity of Se may also be increased in this way. The only previous experiments, made by Bellati and Lussana in 1887, showed an increase in the heat conductivity which agreed well with the increase of the electrical conductivity. The present experiments were made on a single crystal of Se, the thermal conductivity of the crystal being compared with that of glass by a disc method originally devised by Christiansen (cf. Lee's method); but here improved by the addition of a guard ring. A pile of discs—copper, glass, copper, selenium, copper—0·45 cm. high was placed between an electric heater and a brass cylinder through which cold water circulated. Temperatures were measured with copper-constantan thermo-couples, the connections being so arranged that the resistance of the crystal could also be measured. The illumination, provided by a 25-watt tungsten lamp, was sufficient to increase the electrical conductivity nearly 300 %. No change in the ratio of the conductivities of Se and glass in light and darkness could be detected within the temperature-range investigated (10°–74° C.), though the apparatus was sufficiently accurate to detect a change of 5 %.

The experiments showed incidentally that, while both light and dark electrical conductivities of Se increase with rise of temperature, the ratio of the two decreases, *i.e.* the crystal becomes less light-sensitive. D. O. W.

**1482.** *Thermal Properties of Carbon Dioxide at Low Temperatures.* **C. F. Jenkin and D. R. Pye.** (Roy. Soc., Phil. Trans. 215. pp. 353–381, 1915.)—In a former paper [Abs. 1349 (1913)] the authors described a series of measurements on the thermal properties of $CO_2$ and applied the results to the construction of a $\theta\phi$ diagram. This paper contains the further measurements then promised supplying the additional data required for the construction of an accurate total-heat entropy ($I\phi$) diagram.

The experiments on the total heat of $CO_2$, in both gaseous and liquid forms, were repeated with a new calorimeter designed to eliminate radiation and conduction losses; but the general procedure remained the same as before. A steady stream of fluid from a steel weighing flask entered one end of a tubular calorimeter at an observed temperature and pressure; it was there supplied with a known amount of energy by a long heating coil, finally leaving the calorimeter after its temperature and pressure had been measured again. The pressure drop across the calorimeter was indicated directly by a differential manometer based on the change of resistance of a steel banjo wire dipping into the mercury of a differential pressure-gauge. The flow of fluid through the circuit was maintained by a two-stage pump larger and more easily controlled than that previously used, and the gas was dried with calcium chloride instead of phosphorus pentoxide. The total heat of the gas for each pressure was measured at several temperatures, so that the variation of the specific heat at constant pressure with temperature was determined within the limits — 30° to + 30° C. and 150 lbs. to 700 lbs. per sq. in. The experiments on the total heat of the liquid were extended down to a temperature of —50° C. and were subject to much smaller errors than before. The new results necessitate a slight shift of the liquid limit curve on the $\theta\phi$ chart previously constructed for temperatures below —20° C.; but the max. change, at —50° C., is only 0·0054 carnot.

A series of experiments on the throttling of the superheated gas served as a check on the whole work. These were made in sets, those belonging to one set all having the same initial conditions but expanding to a fixed series of lower pressures—thus corresponding to one I-line on the $\theta\phi$ diagram. This method is necessary in view of the manner in which the results are subsequently applied in testing and correcting the accuracy of the charts. A large-scale $I\phi$ diagram with skew co-ordinates accompanies the paper as a folding plate. This has been plotted, not from the $\theta\phi$ diagram, but as far as possible from the original data, the chart being checked and corrected by means of a number of theoretical tests devised by the authors. The theory of the methods used in making these calculations is explained in the appendices at the end of the paper. D. O. W.

1433. *Critical Temperature of Mercury.* **J. Bender.** (Phys. Zeits. 16. pp. 246–247, July 15, 1915.)—According to J. Koenigsberger's experiments the critical temperature of mercury should be about 1270° C. Already by 1200° the meniscus of liquid mercury disappears, and from this temperature onwards a rapid decline of light emission is observed. W. C. Menzies opines that 1270° is too low for the critical temperature, and regards the disappearance of the meniscus not as due to attainment of the critical point, but to the change of capillarity. The present experimental investigation was undertaken to afford more definite information on this subject, and consisted in observing the vapour tension of mercury in closed vessels at high temperatures. The critical point was found to lie above 1500°, and is about 1650° C. An interesting property of Hg-vapour was found between 1200° and 1300°, when the hitherto perfectly transparent vapour began to emit a faint blue light the intensity of which increased with rising temperature. H. H. Ho.

1434. *Gaseous Combustion at High Pressures.* **W. A. Bone,** with **H. Davies, H. H. Gray, H. H. Henstock,** and **J. B. Dawson.** (Roy. Soc., Phil. Trans. 215. pp. 275–318, 1915.)—The authors have employed an apparatus specially designed by Petavel for the accurate investigation of the mechanism of gaseous combustion under high initial pressures, using mixtures of known composition. The complete installation, which is described in detail, includes apparatus for preparing, purifying, and storing the various gases, for separately compressing each gas into steel cylinders up to pressures of between 50 and 100 atmos., for exploding accurately prepared mixtures under known initial pressures in steel bombs of different shapes and capacities so as to obtain reliable data for the interpretation of the chemical changes involved, and for obtaining complete graphs of the pressure-changes involved in the explosions of simple gaseous mixtures of known composition.

Experiments were first made at various pressures with mixtures varying from $2CH_4 + O_2$ to $CH_4 + O_2$, and in interpreting the results distinction is made between (1) the primary oxidation of the hydrocarbon, which is an exceedingly rapid process and is probably completed during the short interval between ignition and the attainment of max. pressure, and (2) certain probable secondary interactions the influence of which may extend far into the subsequent long cooling period. As regards the primary oxidation, the results with $2CH_4 + O_2$ are inconsistent with any idea of a preferential burning, whether of carbon or hydrogen. On the assumption that the oxygen initially enters the methane molecule, forming unstable "hydroxylated" molecules which then decompose, the probabilities of the direct formation of $CH_3.OH$ and $CH_2(OH)_2$ are considered, together with the nature of their respective decomposition products at high temperatures and the magnitude of the corresponding heat-changes. The "hydroxylation" theory is shown to be capable of accounting for the following outstanding facts, brought out by the author's experiments: (1) the ultimate formation of large proportions of both carbon and steam in the explosion of the mixture, $2CH_4 + O_2$; (2) the disappearance of carbon from the products when the proportion of oxygen in the mixtures exploded exceeds 40%; (3) the occurrence of oxides of carbon and steam in the products of all the mixtures fired.

Explosions of a series of mixtures, $CH_4 + O_2 + xH_2$, in which $x$ varied from 2 to 8, were next carried out.

Investigations in which the three mixtures, $2H_2+O_2+4N_2$, $CH_4+O_2+4N_2$, and $2CO + O_2 + 4N_2$, were fired at an initial pressure of about 50 atmos. showed that the hydrogen-air mixture is by far the fastest burning of the three, the max. pressure being reached in approximately $\frac{1}{10}$ of the time taken with the slowest burning CO-air mixtures, namely, 0·01 sec. compared with 0·1 sec. With the methane-air mixtures, this time is 0·05–0·08 sec., that is, at least five times as long as in the hydrogen-air mixtures, in spite of the fact that the affinity of methane is about 20 times that of hydrogen for oxygen in flames. There seems, then, to be no direct relation between the actual rate at which the potential energy of an explosive mixture is transferred on explosion as sensible heat to its products and the magnitude of the chemical affinity between its combining constituents. Attention is drawn to the extreme slowness of the cooling after the attainment of max. pressure in such explosions. This is particularly marked with methane-air mixtures, in which scarcely any appreciable cooling occurred during an interval of 0·22 sec. This circumstance may possibly be attributed to (1) the combustion taking place in well-defined chemical stages, and to (2) the operation of the exothermic secondary interaction between CO and steam during the cooling period. T. H. P.

**1435.** *Radiant Energy, Temperature, and Brightness of a Black Body.* **M. Pirani and H. Miething.** (Deutsch. Phys. Gesell., Verh. 17. 18. pp. 219–289, July 15, 1915.)—Forms an investigation of the efficiency of the black body as a light-source. An expression is first found for the brightness of the body, $H_T$, in terms of the absolute temperature, T. Then if $W$ = the total energy radiated by a body of unit surface-brightness, while $w$ = the portion of this energy which lies within the visible spectrum, then $N = w/W$ is the ratio of the "light" to the total energy. Suppose $n$ per cent.

of the "light" energy ($w$) falls within 540–570 $\mu\mu$, the region of max. sensitivity of the eye, while $m$ per cent. of the whole brightness is due to this energy ($m$ is, of course, greater than $n$), then the energy radiated by an "ideal" light-source of unit brightness is $wn/m$. Assuming Ives's sensitivity curve for the eye, the values of $H_T$ are calculated for all temperatures between 1800° and 5000° abs. and are plotted in the original article, together with indicated points representing experimental values obtained by various observers. The agreement is seen to be very good in general. The two values obtained for tungsten lie exceedingly close to the curve, showing that this metal radiates very nearly as a grey body within the visible spectrum [see Abs. 706 (1915)]. In the equation connecting brightness and temperature, usually written $(H_1/H_2) = (T_1/T_2)^x$ the value of $x$ is found to vary from 19·7 at 1200° to 5·2 at 5000° abs. with a probable value of 2·5 at 10,000°. The ratio of "light" to total energy ($s/S$) is plotted against absolute temperature, and the curve obtained is given in the paper. The temperature of the sun is estimated as 5800° approx., while it is concluded that the efficiency of an "ideal" light-source would be 0·014 watt per mean spherical Hefner candle.

J. W. T. W.

1436. *Total Radiation from a Gaseous Explosion.* **W. M. Thornton.** (Phil. Mag. 30. pp. 383–394, Sept., 1915.)—The argument by which the lost pressure or suppressed heat of a gaseous explosion is made to depend on the mechanics of two colliding and cohering spheres [see Abs. 1692 (1914)] is extended to the case of radiation. In the case of two atoms of equal mass $m$ approaching one another with equal velocity $v$, and having equal rotational and translational energies, the total loss of translational energy in collision is shared between vibration and rotation. If equally shared the total radiation under these conditions should be ¼ of the energy of combination, whereas the experimental value found by Hopkinson and David was 22 %. An explosion may therefore be regarded as (1) a process such as ionisation by collision causing a loosening within the molecules of both gases, (2) attraction between ionised oxygen and combustible gas atoms, resulting in a violent rush together, the total translational energy of which is the heat of combustion, (3) formation of products of combustion having a mean translational energy one-half that of the combining atoms, mean rotational energy ¼, and vibrational energy (radiation) ¼ of it. The comparative slowness and the persistence of the radiation indicates that the interchange of energy between, say, rotation and vibration appears to be slower than between translation and rotation.

J. W. T. W.

1437. *Quantum Theory of Radiation and the Structure of the Atom.* **N. Bohr.** (Phil. Mag. 30. pp. 394–415, Sept., 1915.)—The author's theory of the atom has not escaped criticism, thus, as experimental evidence of importance has been obtained in the meantime, the subject is again considered more closely. According to the theory of E. Rutherford, in order to account for the phenomena of scattering of $\alpha$-rays, the atom consists of a central positively-charged nucleus surrounded by a cluster of electrons. The nucleus is the seat of the essential part of the mass of the atom, and has linear dimensions exceedingly small compared with the distances apart of the electrons in the surrounding cluster. From the results of experiments on scattering of $\alpha$-rays, Rutherford concluded that the charge on the nucleus corresponds to a number of electrons per atom approximately equal to half the atomic weight. Concordant evidence from a large number of very different phenomena has led to the more definite assumption that the number of electrons per atom is exactly equal to the atomic number, *i.e.* the number of the corresponding element in the periodic table. This view was first proposed by van den Broek. While the nucleus theory has been of great utility in explaining many important properties of the atom, it is impossible by its aid to explain many other fundamental properties if we base our considerations on the ordinary electrodynamical theory; but this can hardly be considered as a valid objection at the present time. It does not seem that there is any escape from the conclusion that it is impossible to account for the phenomena of temperature radiation on ordinary electrodynamics, and that the modification to be introduced in this theory must be essentially equivalent to the assumptions first used by Planck in the deduction of his radiation formula, known as the quantum theory. In the present author's previous paper it was attempted to apply the main principles of this theory by introducing the following general assumptions: (A) An atomic system possesses a number of states in which no emission of energy radiation takes place, even if the particles are in motion relative to each other, and such an emission is to be expected on ordinary electrodynamics. The states are denoted as "stationary" states of the system under consideration. (B) An emission or absorption of energy radiation will correspond to the transition between two stationary states. The radiation emitted during such a transition is homogeneous, and the frequency $\nu$ is determined by the relation $h\nu = A_1 - A_2$...(1), where $h$ is Planck's constant and $A_1$ and $A_2$ are the energies of the system in the two stationary states. (C) That the dynamical equilibrium of the systems in the stationary states is governed by the ordinary laws of mechanics, while these laws do not hold for the transition from one state to another. (D) That the various possible stationary states of a system consisting of an electron rotating round a positive nucleus are determined by the relation $T = \frac{1}{2}nh\omega$...(2), where T is the mean value of the kinetic energy of the system, $\omega$ the frequency of rotation, and $n$ a whole number.

It may be seen that these assumptions are closely analogous to those originally used by Planck about the emission of radiation in quanta and about the relation between the frequency of an atomic resonator and its energy. It can be shown that for any system containing one electron rotating in a closed orbit, the assumption C and the relation (2) will secure a connection between the frequency calculated by (1) and that to be expected from ordinary electrodynamics, in the limit where the difference between the frequencies of rotation of the electron in successive stationary states is very small compared with the absolute value of the frequency. On the nucleus theory this occurs in the region of very slow vibrations. If the orbit of the electron is circular, the assumption D is equivalent to the condition that the angular momentum of the system in the stationary states is an integral multiple of $h/2\pi$. The possible importance of the angular momentum in the discussion of atomic systems in relation to Planck's theory was first pointed out by J. W. Nicholson.

The present author has previously shown that the above assumptions led to an interpretation of the Balmer formula for the hydrogen spectrum, and to a determination of the Rydberg constant which was in close agreement with the measurements. The assumption A has recently obtained direct support by experiments of A. Einstein and J. W. de Haas, who have succeeded in detecting and measuring a rotational mechanical effect produced when an iron bar is magnetised. These results agree very closely with those to be expected on the assumption that the magnetism of iron is due to rotating electrons, and, as pointed out by Einstein and Haas, these experiments therefore indicate very strongly that electrons can rotate in atoms without emission of energy radiation.

When we try to apply assumptions analogous to C and D to systems containing more than one electron, we meet with difficulties, since in this case the application of ordinary mechanics in general does not lead to periodic orbits. An exception to this, however, occurs if the electrons are arranged in rings and rotate in circular orbits, or from simple considerations of analogy the following assumption was proposed: (E) In any atomic or molecular system consisting of positive nuclei and electrons in which the nuclei are at rest relative to each other, and the electrons move in circular orbits, the angular momentum of each electron round the centre of its orbit will be equal to $h/2\pi$ in the "normal" state of the system, *i.e.* the state in which the total energy is a minimum. In a number of different cases this assumption led to results in approximate agreement with experimental facts. In general, no stable configuration in which the electrons rotate in circular orbits can exist if the problem of stability is discussed on ordinary mechanics. This is no objection, however, since it is assumed already that the ordinary mechanics does not hold for the transition between two stationary states. Simple considerations led to the following condition of stability: (F) A configuration satisfying the condition E is stable if the total energy of the system is less than in any neighbouring configuration satisfying the same condition of angular momentum of the electrons.

The author considers the criticisms of J. W. Nicholson [Abs. 1246, 1882 (1914)], but, while admitting that the points under discussion involve great and unsolved difficulties, is unable to agree with Nicholson's conclusions.

The spectra emitted from systems containing only one electron are then considered, and next those from systems containing more than one electron, this being followed by a discussion of the high-frequency spectra of the elements. It is assumed in these sections that the spectra considered are due to the displacement of a single electron. If several electrons should happen to be removed from one of the rings by a violent impact, some of the considerations adduced would not apply, since the electrons removed in this case could be replaced by those in the other rings. Thus there might possibly be a rearrangement of the electrons (after the removal of more than one of them) that would give rise to spectra of still higher frequency than those considered. [See Abs. 811 (1914).] E. H. B.

**1438.** *Space Variation of Radiant Heat.* **T. Levi-Civita.** (Accad. Lincei, Atti, 23. pp. 371–379, Nov. 18, and pp. 458–464, Dec. 2, 1914.)—Most researches on radiant heat deal with stationary conditions, such as those under which a cavity has acquired a uniform and constant temperature throughout. The author calls attention to cases of the type in which the cavity has not yet acquired the temperature of the heater, or, more particularly, where the surroundings are maintained at temperatures varying from point to point but constant in time. This implies that Planck's "specific intensity of radiation" is no longer independent of the orientation of the surface element. The flux of heat energy is given by $F = -4\pi k \operatorname{grad} K$, where K is the specific heat intensity and $k$ a positive function of the absolute temperature. The most general equation for the propagation of heat is of the form—

$$1/c \,.\, \partial K/\partial t + \nabla(k_1 K) + k\Delta_2 K = 0.$$

E. E. F.

## SOUND.

1439. *Noise of Breaking Sea-waves.* **T. Terada.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 164–178, July, 1915.)—There are many districts along the Japanese coast where the roaring sound of sea-waves is sometimes heard at quite a considerable distance, say several kilometres, from the nearest shore. For example, in Kôchi (the chief town in the province Tosa), situated 8 km. from the nearest Pacific coast, it is of very frequent occurrence, especially in summer and autumn, that a hollow rolling sound of waves is heard so loudly that those ignorant of the actual situation could hardly realise the fact that it originates at a distance of 8 km. The one alleged peculiarity of the sound is that the apparent intensity does not sensibly increase when we approach the shore, *i.e.* the sound is heard at a distance of several km. as distinctly as at 1 km. This peculiarity may probably be explained if we consider that the sources of sound are distributed on a long coast line, instead of concentrated at a single spot. Thus, the law of the intensity, apart from special disturbances, would be nearly that of the inverse distance, instead of the inverse square.

Tests with Helmholtz's resonators showed that sounds of many pitches were present in the roaring and that these sounds were intermittent. The frequency of intermittence was also higher for the higher tones. Thus, for $\text{Ut}_2$ (128) the intermittences were 3 or 4 per sec., for $\text{Ut}_3$ (256) 10 to 12, and for $\text{Ut}_4$ (512) they were above 16 per sec.

A mathematical theory is developed and optical analogies are pointed out.
E. H. B.

1440. *Effect of Temperature on Hissing of Water Flowing through a Constriction.* **S. Skinner** and **F. Entwistle.** (Roy. Soc., Proc. 91. pp. 481–485, Aug. 2, 1915.)—These experiments lead to the conclusions :—(1) That the phenomenon of hissing of water passing a constriction is due to a true rupture of the stream at the point where the pressure is lowest. (2) That the temperatures at which the hissing just occurs, between 0° and 100° C., follow a law which may be expressed by $V = C(\theta - t)$ ; where V is the velocity of the stream at a temperature $t$, $\theta$ the critical temperature of water, and C is a constant.
E. H. B.

1441. *Architectural Acoustics.* **F. P. Whitman.** (Science, 42. pp. 191–198, Aug. 6, 1915.)—Describes the acoustical defects of the Chapel of Adelbert College, its investigation and cure. The ordinary sounding board of the canopy type, about 6 ft. in diam. and suspended about 2 ft. above the head of the speaker, was first tried, but was without noticeable effect. There was no evidence of special or local echoes. The difficulty was plainly one of excessive reverberation, due to the insufficient absorbing power of the walls and ceiling. The ceiling is of wood, the walls are of stone, part bare and part covered with plaster laid directly upon the stone.

Under the counsel of W. C. Sabine the ceiling was covered with felt 2 in. thick and the walls down to the springing of the window arches with felt 1 in. thick. The appearance was unchanged. The experiments to test the value of the change extended over a college year, namely, one semester before the felting (which was carried out in the summer vacation of 1914) and one semester after. The college chapel is used for an address four times per week, the speaker being the same throughout the week and changed for the next week. Observers sat at various places, A, V, and Q, and noted the percentage of words heard distinctly apart from the context. Then an average for all the speakers was taken. The results are as shown in the table.

AVERAGE OF ALL SPEAKERS.

| Place. | Percentage heard distinctly. | |
|---|---|---|
| | First Semester. | Second Semester. |
| A.............................. | 71 | 91 |
| V.............................. | 71 | 96 |
| Q.............................. | 95 | 100 |

The actual improvement is really greater than appears from these averages. Thus, for one of the less distinct speakers the percentage heard before the treatment with felt was only 10, whereas after it was 76. Of the different speakers, 6 were heard in both semesters; their average for the first being 64 % and for the second 92 %. E. H. B.

**1442.** *Character of the "S" Sound.* **Rayleigh.** (Nature, 95. pp. 645–646, Aug. 12, 1915.)—Some two years ago the author asked for suggestions as to the formation of an artificial hiss and remarked that the best so far achieved by him was by blowing through a rubber tube nipped at about ½ in. from the open end with a screw clamp, but that the sound so obtained was perhaps more like an *f* than an *s*. Among the replies received was one from E. B. Titchener, who wrote: "Rayleigh's sound more like an *f* than an *s* is due, according to Köhler's observations, to a slightly too high pitch. A Galton whistle, set for a tone of 8400 v.d., will give a pure *s*" [see Abs. 1812 (1913)]. Further work was afterwards done on the subject by Titchener and by the present author, who finally concludes that no pure tone gives the full impression of an *s*. The position held is that the vibration is irregular. A fairly defined pitch does not necessitate regular sequences of more than a few (say 8–10) vibrations. Thus the *s* may be comparable to an organ pipe which does not speak well, to a violin string badly bowed, or the drops from a liquid jet. E. H. B.

## ELECTRICITY AND MAGNETISM.

### THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1443. *Metallic Conduction.* **O. W. Richardson.** (Phil. Mag. 30. pp. 295–299, Aug., 1915.)—Discusses some of the interesting questions suggested by the theory of metallic conduction recently revived and extended by J. J. Thomson [Abs. 1085 (1915)]. According to this theory the electrons are projected, from the atoms at which they originate, in directions coinciding with the axes of the electric doublets supposed present in the atoms. A numerical application to tungsten is made, which is thus calculated to have $6{\cdot}16 \times 10^{22}$ atoms per cm.$^3$. E. H. B.

1444. *Electron Theory of Metallic Conduction.* IV. **G. H. Livens.** (Phil. Mag. 30. pp. 287–295, Aug., 1915.)—The concluding part of this series in which reference is made to the work of Enskog [Abs. 1686 (1912)] and Bohr. Bohr's analysis is based on the idea of momentum distribution, whereas that of the present author is based on velocity distribution. [See Abs. 1086 and 1302 (1915).] E. H. B.

1445. *Mutual Electromagnetic Mass.* **L. Silberstein.** (Phil. Mag. 30. pp. 370–372, Sept., 1915.)—Mathematical; refers to results previously obtained [Abs. 505 (1911)].

1446. *On Waterfall Electricity and on the Surface Condition of Liquids.* **P. Lenard.** (Ann. d. Physik, 47. 4. pp. 463–524, July 8, 1915.)—The present communication forms part of a larger work on the problem of complex molecules. [See also Abs. 1320 (1913).] Under the name "Waterfall-electricity" the author includes the electrical phenomena accompanying waterfalls, splashing brooks, and rain, also water-jets and drops as produced in the laboratory. In these cases the water becomes positively electrified while the negative charge passes into the air. Experiments have also been undertaken of bubbling air through water and of breaking water into spray, and the same phenomena found, so that these latter are classified under waterfall effects. For explaining these electrical accompaniments the liquid surfaces are assumed to be the seat of an electrified double layer, and the observed effects are due to the separation of this double layer whereby a charge of one sign remains in the liquid while the opposite one passes into the surrounding atmosphere. The varying forms of the effect are due to the different modes of separation. The present paper contains an investigation into the mechanism of the waterfall effect, and into the behaviour of liquid surfaces considered as the seat of electrical and material stratification. Section I deals with the superficial concentration of complex molecules and the forces operating on them. Here the idea of complex molecules receives detailed explanation, their distribution in the surface layer is considered, and the dimensions of the superficial forces comprehensively treated. Section II deals with the waterfall effect as a consequence of the electrical nature of the molecular forces. First comes a detailed treatment of the electrified double layer at the surface; the surface tension is found to be not much different *in vacuo* to its value in air, while there is no frictional electricity developed between water and air. The rapid disappearance of liquid surface, *e.g.* by impact on a wetted surface, by water-drops falling into water, or by coalescence of drops, is next considered, and the conclusion drawn that the separation between air and water is not the active agent in the production of the waterfall effect. Ordinary distribution of fluid is ineffective; spraying, on the other hand, brings about the effect, and in general the separation of very small liquid particles from the surface acts as a fundamental cause. The waterfall theory of thunderstorms is next exhaustively discussed. Important evidence that contact electricity between gas and liquid is not the origin of waterfall effects is afforded by the very small influence which the nature of the gas exerts, comparative experiments having been undertaken with hydrogen, methane, nitrogen, carbon monoxide, air, and oxygen. Section III deals especially with the surface condition of fluids. Every liquid surface has been found to consist of a number of strata which are both electrically and materially different from each other, and such stratification extends to a depth equal to the sphere of activity. From a knowledge of these strata may be gathered an insight into such surface phenomena as surface tension, waterfall effect, photoelectric activity, etc., also the influence of dissolved substances. Purely dielectric fluids such as water, alcohol, benzol, are first considered, the surface constitution, the field-strength of the double layer, and the waterfall effect being critically examined. Following this comes the behaviour from every standpoint of dissociated non-volatile electrolytes, *e.g.* dilute aqueous salt solutions, and a comparison is made by varying the anions and kathions. The nature of the carriers of the various electrical effects is next discussed. Partially dissociated non-volatile electrolyte, *e.g.* concentrated salt solutions, then receive attention, followed by undissociated non-volatile fluids—for instance, sugar solution. Solutions of volatile solutions such as aqueous solutions of HCl, $NH_3$, alcohol, and ether are then treated, and finally the surface behaviour of metallic mercury is considered. Some of the general conclusions are as follows:—A simple expression has been found for the surface concentration of solutions of non-volatile substances and analogous fluid mixtures. An insight was afforded into the surface behaviour of liquids containing molecules of different dimensions by an investigation into the dependence between the molecular surface forces and molecular volumes. It has been shown in six different ways that the electrified double layer whose presence at liquid surfaces is shown by the waterfall effect, does not originate through contact electricity between gas and fluid, but that its seat is entirely within the fluid in such a way that the external molecular layer is negatively, and the interior layer positively charged. The cause of this double layer lies in the electrical nature of the molecular forces, and in like manner can be regarded the phenomenon of contact electricity on dielectric bodies. The different forms of the waterfall effect, as also its presence under certain conditions and its absence in others, are explained from the standpoint of disturbance experienced by the electrified double layer. The waterfall theory of thunderstorms now appears probable since the discrepancies hitherto attached to it have been removed by the preceding results. A large number of singularities accompanying the waterfall effect, together with the photoelectric activity and the surface tension of different fluids, can be traced to their surface conditions. H. H. Ho.

**1447.** *Atmospheric-electric Observations on the Third Cruise of the "Carnegie,"* 1914. **W. F. G. Swann.** (Terrest. Magn. 20. pp. 13–48, March, 1915.)—The general course covered by the cruise was from Brooklyn (left June 8) to Hammerfest in northern Norway; from Hammerfest (July 25) northward to latitude 79° 52′ N. in the neighbourhood of Spitzbergen, and then south-westward to Reykjavik in Iceland (Aug. 24) and so back to Brooklyn. The measurements discussed in the present report are those of potential gradient, conductivity, and the radio-active content of the air. Potential gradients were measured by the use of an ionium collector projecting from the stern of the ship connected to a Wulf bifilar electroscope. The standardisation of this apparatus was carried out by means of simultaneous ship and shore observations on two occasions. The conductivity was measured by Gerdien's method and a few observations were also taken of the ionic numbers. The radio-active content was measured by the stretched-wire method of Elster and Geitel with certain modifications devised by the author. There is some uncertainty as to what the measurements obtained by this method really mean, and a considerable amount of discussion is devoted to the point.

The mean potential gradient found on the voyage was 93 volts/m. The measurements were made between 9 a.m. and noon, at which period of the day Simpson and Wright found in the South Atlantic a mean value of 80 volts/m.; so that, considering the difficulties in the way of obtaining absolute readings, there is a fair agreement between the two results. The mean conductivity was $2{\cdot}52 \times 10^{-4}$ e.s. unit. This is rather greater than the average value found on land. Passing out to sea from the American shore, the conductivity appears first to fall somewhat below the normal land value and then increases again as the vessel gets out into the open sea. This distribution was observed both on leaving and returning to the shore. The local decrease near the shore is found to be due to a low value of the specific velocity of the ions in the same region. The electrical results have been grouped in various ways with the different meteorological elements but no marked relationships are found. In discussing the radio-active content, the mean value expressed in Elster and Geitel units is found to be 23, corresponding to about $12 \times 10^{-12}$ curie of RaEm per m.$^3$. This amount is much smaller than would be necessary to account for the conductivity of the air. A similar result has been found by most observers. In the latter portion of the paper an application of the theory of radio-active disintegration is made to the decay curves obtained in the Elster and Geitel method, and it is found that while some of the curves can be accounted for by the presence of RaEm alone in the atmosphere others appear to require the presence of some more slowly decaying products than those of RaEm. J. S. Di.

## DISCHARGE AND OSCILLATIONS.

**1448.** *Residual Ionisation in Gases.* **J. C. McLennan** and **C. L. Treleaven.** (Phil. Mag. 30. pp. 415–427, Sept., 1915.)—From observations made by Simpson and Wright [Abs. 1196 (1911)], McLennan and McLeod [Abs. 493 (1914)], and others, it is known that the ionisation in air confined in air-tight clean zinc vessels is about 8 or 9 ions per cm.$^3$ per sec. when the observations are made on land where the soil contains only such minute traces of radio-active substances as are found in ordinary clays. It is also known that when the observations are made over large bodies of water (oceans, seas, and large lakes) the ionisation in air confined in this manner drops to approximately 4 ions per cm.$^3$ per sec. The authors discuss the possible explanation of this residual conductivity of 4 ions per cm.$^3$ per sec. which persists when all known external radiations are cut off from the vessel containing the air. A Wolff electrometer was used in the ionisation measurements. They conclude from their experiments made on the ice of Lake Ontario that the residual ionisation observed in air, $CO_2$, hydrogen, nitrous oxide, and ethylene is not spontaneous, even in part, but is due to a radiation emitted by the zinc walls of the electrometer. This radiation consists of $\alpha$- and $\beta$-rays, and possibly $\gamma$-rays.

The residual ionisation in acetylene has been shown to be exceptionally high, 27 ions per cm.$^3$ per sec., and evidence has been adduced which goes to show that this ionisation cannot be due to a radiation of the $\alpha$-, $\beta$-, or $\gamma$-type, but that it must to a considerable extent be due either to molecular collisions or to a spontaneous disruption of the atoms or molecules that constitute the gas. [See next Abstract.] A. B. W.

1449. *Residual Ionisation in Air enclosed in a Vessel of Ice.* **J. C. McLennan** and **H. G. Murray.** (Phil. Mag. 30. pp. 428–434, Sept., 1915. Paper read before the Roy. Soc. of Canada, May, 1915.)—Values lying between 4 and 5 ions per cm.$^3$ per sec. have been obtained by numerous observers as the measure of the natural ionisation in air confined in pure zinc vessels—the observations in such cases being made over large bodies of water in order to eliminate the effects of the earth's penetrating radiation. This conductivity of 4 ions per cm.$^3$ per sec. may possibly be accounted for in several ways, a few of which are suggested by the authors. The object of the research now described is to test the correctness of the view that the conductivity of the air is due to ionisation produced by a radiation from the walls of the zinc containing-vessel. Experiments have been made on land and over water with air-containers of zinc and ice. The results of the investigation are summarised as follows :—The mean value found at land stations near Toronto for the electrical conductivity of air confined in zinc vessels of highest purity is represented by the generation of 7·62 ions per sec. The mean value found for the conductivity of air enclosed in the same zinc vessels has been shown to be represented by the generation of about 4·5 ions per cm.$^3$ per sec. when the experiments were made on the ice of Toronto Bay, Lake Ontario. With air confined in a vessel of ice made from the water of Lake Ontario (practically free from radio-active matter) the conductivity of air when measured on the surface of that lake is represented by 2·6 ions per cm.$^3$ per sec., which is the lowest conductivity hitherto observed for air. Reasons have been given which support the view that air has no electrical conductivity apart from that impressed upon it by radiations traversing it which are emitted by the walls of the containing vessel, and by the land, the atmosphere, and the water in the neighbourhood of the enclosed air the conductivity of which is being measured. A. B. W.

1450. *Mobility of Negative Ions at Low Pressures.* **J. J. Thomson.** (Phil. Mag. 30. pp. 321–328, Sept., 1915.)—From the work of Franck and Pohl and of Wellisch [Abs. 1099 (1915)] it seems that the electron can traverse in a free state distances which are large compared with the mean free path. The present paper discusses the theory of a well-known method of measuring the mobility of ions in reference to this fact. The case considered is that where charged particles are moving under a uniform electric field through a gas enclosed between two parallel plates, distance apart $d$, set perpendicular to the lines of electric force. In such experiments the quantity measured is often the charge Q received by one plate during an interval of time T when a layer of gas close to the other plate is ionised at the beginning of the interval by a flash of Röntgen rays. Then $Q = 0$ until $T = d/k_1X$ and, apart from recombination losses, all the ions reach the plate if $T = d/k_2X$; where $k_1$ and $k_2$ are the mobilities of electron and ion and X is the electric force between the plates. When T is between these limits an expression for Q is found here on the assumption that the negative ions are formed in such a way that they commence as electrons though some of them ultimately unite with the gas molecules. It is supposed that once an electron becomes attached to a molecule it reaches the electrode before again getting free. It is shown that the expectation of an electron travelling a distance $x$ perpendicular to the plates in a free state is $e^{-ax/n\lambda}$, where $1/n$ is the chance of an electron combining with a molecule on collision, $ax$ is the total distance traversed by the electron including the zigzag heat motions and $a = V/k_1X$, V being velocity of the electron due to thermal agitation. Thus if N electrons start from $x = 0$, $Ne^{-ax/n\lambda}$ traverse a distance $x$ without recombination. Considering a particle which takes the whole time T to get from one plate to the other, travelling a distance $x$ as an electron, $d - x$ as an ion, it is seen that $x = (d - k_2XT)/(1 - k_2/k_1)$. All the electrons which reach $x$ without combining will be in time to deliver up their charge, while those combining before travelling this distance will be too late. Thus the charge received by the plate will be the charge carried by those electrons that travel the distance $x$ without combining, that is, $Q = N\epsilon . e^{-\frac{a}{n\lambda}\frac{d-k_2XT}{1-k_2/k_1}}$; $\epsilon$ being the electronic charge. Hence Q is a function of T, X, $d$, gas pressure and temperature. The variation of Q with these quantities is considered, and it is seen that the mobility of the negative ion as measured by its average velocity over a given distance when acted on by a given electric force is not a definite quantity: particles can be found possessing any mobility provided this is between $k_1$ and $k_2$. Thus the number of particles which have mobility not less than $k$ is $Ne^{-\beta}$, where $\beta = \frac{d}{n\lambda} \cdot \frac{1 - k_2/k}{1 - k_2/k_1} \cdot \frac{V}{k_1X}$.

The case is also considered when the ionisation at the plate is continuous rather than due to a flash at the beginning of the interval of time.

It is pointed out that there are, at present, except in the case of flames, no direct determinations of $k_1$. These would be of great value. The advantage possessed by the electron is that there is no uncertainty as to its nature; it is, unlike the negative ion, the same whatever its nature, temperature, or pressure of the gas. The uncertainty as to the size of the ion makes ambiguous the evidence as to the nature of the action between ions and molecules afforded by such phenomena as variation of mobility with temperature or pressure. T. H.

1451. *Influence of Gases on the Emission of Electrons and Ions from Hot Metals.* **O. W. Richardson.** (Roy. Soc., Proc. 91. pp. 524–535, Sept. 1, 1915.)—It is well known that the saturation density $i$ of the electron currents from hot bodies can be represented accurately by the formula $i = AT^{\frac{1}{2}}e^{-b/T}$, where T is the absolute temperature and A and $b$ are constants characteristic of the substance. A and $b$ are functions of the nature and pressure of the surrounding gas as well as of the hot metal; they are independent of temperature within the limits in which the formula is valid. For Pt heated in hydrogen H. A. Wilson has shown that $b = c \log A + d$, where $c$ and $d$ are constants. In the present paper it is shown that a similar relation holds for tungsten when the changes in A and $b$ are caused by traces of various gases. It seems probable that the relation holds in general; there is evidence that it is independent of the particular gas effecting the changes and that it also applies to positive ions as well as negative. Curves, log A and $b$, are plotted for Pt and W, the latter containing all the available reliable data. One important difference is that for tungsten the pure metal has small values of the constants which are increased by gaseous contaminants, whereas the opposite holds for Pt.

The general theory of the effects of gases on the emission constants is considered. The methods already used for pure metals are extended on the assumption that a contaminated surface may be regarded as a pure surface covered with a layer of uniform composition of contaminated metal to a small but finite thickness. It is then necessary to take into account the contact p.d. and the Peltier e.m.f. between the pure and contaminated materials. Various relations are proved and it is shown that $i/i_1 = \epsilon^{-\epsilon V_1/kT}$, where $i$ and $i_1$ are the saturation currents for the impure and pure metals, $V_1$ the contact p.d. between the pure and contaminated surfaces, $\epsilon$ the electronic change, and $k$ is Boltzmann's constant. Knowing $i_1$, this gives $i = AT^{\frac{1}{2}}\epsilon^{-(b+\phi)/T}$, where $\phi = \epsilon V_1/k$. $\phi$ may depend on the temperature as well as pressure, and it is shown that it must be of the form $\phi = a_0 + a_1T$, where the coefficients are functions of the pressure. If C and $d$ are the values of A and $b$ with the gas present, $\log C - \log A = -a_1$ and $d - b = a_0$. To satisfy the linear relation between log A and $b$, the ratio $-(a_1/a_0)$ must be a positive quantity independent of gas pressure; for tungsten $-(a_1/a_0) = 4{\cdot}16 \times 10^{-4}$, for Pt, $4{\cdot}86 \times 10^{-4}$. Putting $-(a_1/a_0) = a$, $\phi = a_0(1 - a\tau)$ so that $\phi$ has the sign of $a_0$. For tungsten $a_0$ is positive so that gaseous contamination makes the metal electro-negative to pure metal, the actual change being $V_1 = -k/\epsilon . a_0 (1 - aT) \times 300$ volts. For Pt the sign is negative, so that contamination with hydrogen makes the metal more electro-positive; the magnitude of the change is comparable with that for tungsten.

The evidence for the linear relation between log A and $b$ is also discussed for the positive emission from an old Pt-wire in various gases. The observed linearity is hardly likely to be due to a coincidence, but further investigation is needed. The ratio $-(a_1/a_0)$ is of the same order as for negative emission. It is pointed out that the opposite changes in the emission constants of W and Pt caused by hydrogen are probably attributable to a similar cause acting in opposite senses in the two metals; thus if the change in Pt is due to positive ions in the surface layer it is equally likely that the contrary effect with tungsten is due to negative ions. It is noted that the effect of hydrogen on the constant $a_0$ for the positive emission from Pt is opposite to that for the negative and is in the same sense as the negative emission from tungsten.

T. H.

**1452.** *Probability of Ionisation and Radiation of Gas Molecules due to Collision with Electrons.* **K. F. Nesturch.** (Phil. Mag. 30. pp. 244–248, Aug., 1915. Paper read before the Russian Physico-Chem. Soc., Dec. 22, 1914.)—As recently shown by Franck and Hertz, the electrons in electro-positive gases (He, Ne, Ar, also Hg-vapour), set in motion by the action of an electric field, collide elastically with neutral gas molecules. Consequently when passing a fall of potential, the electrons accumulate kinetic energy independently of the number of collisions on their way, *i.e.* independently of the pressure of the gas. [See Abs. 1588 (1914).] When an electron has obtained a certain amount of energy, its next collision with a gas molecule is an inelastic one; it loses its energy, which is then transferred to the molecule. The amount of energy, possessed by the electron at the moment of the inelastic collision, is a characteristic quantity for the gas, the corresponding fall of potential being the "ionising potential" of the gas. Franck and Hertz have brought forward numerous arguments in favour of the view that the energy, which an electron loses by this inelastic shock, can either ionise the molecule or force it to emit radiation of a definite wave-length, but that both processes cannot occur simultaneously. To this it may be added that according to the model of the atom, recently designed by N. Bohr, the possibility of such transformation of energy is very obvious in both cases [see Abs. 1930 (1913)]. It is possible to suppose then that the ratio of probabilities of ionisation and radiation is a characteristic property of the gas. In this article the author indicates a method for a rough determination of the numerical values of the above probabilities for electro-positive gases only. It is thus found that within certain limits the probability, $\gamma$, of the ionisation of the gas molecule by an inelastic collision may be nearly proportional to the potential gradient X. Graphs are given showing how this simple relation is departed from. E. H. B.

1453. *Experimental Confirmation of the Lorentz-Einstein Formula for High-speed Kathode Rays.* **C. E. Guye** and **C. Lavanchy.** (Comptes Rendus, 161. pp. 52–55, July 19, 1915.)—The experimental method here adopted is that of *identical trajectories* previously developed by C. E. Guye and S. Ratnovsky [see Abs. 418 (1910)]. A reproduction of the photographs is given. A table of 25 determinations is appended and compared with the theories of Lorentz-Einstein and of Abraham. The former is distinctly supported and not the latter. E. H. B.

1454. *The Kathode-fall in Gases.* **C. A. Skinner.** (Phys. Rev. 6. pp. 158–165, Aug., 1915.)—A continuation of the experimental results in support of the author's theory of the kathode-fall of potential in gases [Abs. 1309 (1915)]. The observed values of the potential at points between the kathode and the negative glow agree with those calculated for normal, twice normal, and four times normal current density. The mobility of the positive ions is deduced, and is about six times the value usually given; the potential gradient per mean free path is, however, much smaller than in the present case. It would thus appear that the mobility of the positive ions, like that of the electrons, increases at low pressures much more rapidly than their mean free path. The ratio of the electron current leaving the kathode to the total current is also calculated, and is found to increase with increasing current density. The author concludes from his results that the "normal" kathode current-density is that giving a minimum kathode-fall, which condition corresponds to a minimum loss of electrical energy in sending a given current through the gas. L. L.

1455. *The Wehnelt Interrupter as a Generator of Electric Oscillations.* **P. Ludewig.** (Jahrbuch d. Drahtl. Teleg. 9. pp. 445–459, April, 1915.)—Nilsson has recently given an account of his experimental work on the above subject [see Abs. 1111 (1915)]. The author attempts to formulate a theory of the action of the interrupter, based on the experimental observations of Nilsson, Wehnelt, Simon, and himself. He considers that the following actions take place at the interrupter itself: (1) The bubbles of oxygen liberated at the Pt electrode reduce the cross-section of the conducting medium; heat is therefore generated and a bubble of water-vapour is formed suddenly. This causes the interruption of the circuit. (2) The p.d. between the Pt and the fluid rises to such a value that the intervening gas layer is pierced by a spark which explodes the gaseous mixture. (3) The fluid again makes contact with the Pt. I. W.

Numerous oscillograms are given and discussed.

## ELECTRICAL PROPERTIES AND INSTRUMENTS.

1456. *Electrical Conductivity of Anisotropic Fluids in Magnetic and Electric Fields.* **T. Svedberg.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 9. 21. pp. 1–11, 1914.)—Additional measurements have been made with azoxyanisol, azoxyanisolphenetol, and azoxyphenetol to determine the influence of electric and magnetic fields on the conductivity of anisotropic fluids. It is shown that the change of conductivity increases as the length of the molecule is increased, but the effects diminish as the "clearing-point" is reached, when they vanish abruptly. In the case of azoxyanisolphenetol and azoxyphenetol no effect is produced by electric fields weaker than 100 volts $\text{cm.}^{-1}$; electric fields of slightly greater strength produce very marked effects on these two compounds, though the closely related compound azoxyanisol is scarcely affected at all. In the case of magnetic fields the action lags over a short period of time, reaching a maximum, for instance, in 160 secs. with a field-strength of 200 gauss and in 90 secs. with a field-strength of 300 gauss. T. M. L.

1457. *The Coefficient of End-correction.* II. **P. J. Daniell.** (Phil. Mag. 30. pp. 248–256, Aug., 1915.)—If an electric current passes through a long cylindrical tube of conducting material, and then out into a large hemispherical volume of the same, the total resistance is proportional to the total length of the tube plus a certain multiple, $k$, of the radius; this is the coefficient of end-correction. In a previous paper [see Abs. 1120 (1915)] the author found $k < 0{\cdot}82168$ by assuming the normal current at the open end to be of the form $A + B(1 - w^2) + C(1 - w^2)^{-1/2}$. In the present paper a method is given by which the approximate value 0·82141, *i.e.* less than the real value of $k$, is obtained. Thus $k$ is confined between the narrow limits $0{\cdot}82141 < k < 0{\cdot}82168$. The method itself is an amplification of one previously used by Rayleigh, and assumes a value for the potential at the open end of the form $A + B(1 - w^2) + C(1 - w^2)^2 + D(1 - w^2)^3$. H. H. Ho.

1458. *Change of Thermoelectric Power on Fusion.* **J. Koenigsberger.** (Ann. d. Physik, 47. 4. pp. 563–565, July 8, 1915.)—The author has previously detected a discontinuity in the thermoelectric power ($e$) of zinc at the melting-point [Abs. 1394 (1911)]. Experiments of Cermak and Schmidt [Abs. 71 (1912)] do not confirm this. Recently, Siebel [Abs. 910 (1915)] has shown that $e(\text{liquid}) - e(\text{solid})$ is positive for Sn, Hg, Pb, and Bi, and negative for Zn and Sb, and has applied the theory of A. L. Bernoulli to the phenomenon. This accounts for the magnitude of the effect, but disagrees in sign except in the case of zinc. Koenigsberger objects to the Bernoulli theory, and shows in the present paper that the earlier Lorentz theory, which is more applicable to the case, accounts for the magnitude of the effect to a nearer degree. The Lorentz theory, however, only gives the correct sign in the case of zinc. The author refers also to the experiments of M. Werner [Abs. 2025 (1914)] on polymorphic transformations. Werner observed a discontinuity in the thermoelectric power of zinc at the transformation temperature of 300°. The Lorentz theory accounts for the sign of this effect, but the calculated value is smaller than that observed. The author points out that on Baedeker's theory there should be no discontinuity on passing from the solid to the liquid state. L. L.

1459. *Mutual Inductances of Circuits composed of Straight Wires.* **G. A. Campbell.** (Phys. Rev. 5. pp. 452–458, June, 1915.)—The mutual inductance between any two circuits made up of $m$ and $n$ straight wires of negligible diam. may be most simply expressed as the sum of the $mn$ mutual Neumann integrals between the sides taken in pairs, one from each circuit. Such inductances are required in practical computations, and the author gives a general formula in convenient form for the mutual Neumann integral between two skew lines of any lengths in any relative location. Formulæ for a number of special cases are also given, and a diagram for use in calculations. F. E. S.

1460. *Most Effective Primary Capacity for Induction Coils and Tesla Coils.* **E. T. Jones.** (Phil. Mag. 30. pp. 224–239, Aug., 1915.)—In the theory put forward in recent papers [Abs. 1314 (1914), 591 (1915)] by the author, the induction coil is regarded as an oscillation transformer, in which the two circuits are closely coupled, and in which the secondary potential arises from the superposition of two oscillations differing in amplitude, frequency, and damping coefficient. The expression for the secondary potential was worked out in certain cases from the "constants" of the circuits, and found to agree closely with experiment both in wave-form and in max. potential as deduced from the observed spark-length. The author now shows how to calculate approximately the optimum primary capacity for a given coil, *i.e.* the capacity which, connected across the interrupter, allows the greatest secondary potential to be developed, when the induction coefficients of the circuits, the secondary capacity, and the primary current are all given. He also shows that Drude's rule for the Tesla coil does not in general give even approximately the correct value of the optimum primary capacity. The most effective capacity is generally greater than the "resonance" value. The calculated values are compared with those obtained experimentally. I. W.

1461. *Vibration Galvanometer of High Sensitiveness for Low Frequencies.* **H. Zöllich.** (Archiv f. Elektrotechnik, 40. pp. 369–388, Aug., 1915.)—After discussing the scope of various null-instruments for use in a.c. bridge measurements and the different principles on which vibration galvanometers may be constructed, the author describes a new instrument of the bifilarly suspended coil type, developed by Siemens and Halske. In one type only a small range of frequency adjustment is provided, about ± 2% of the nominal frequency. The other type is adjustable from 15–30, 25–60, 50–500, according to the range required. Coarse adjustment is made with a moving bridge-piece, and fine adjustment with a tension-nut. Permanent magnets are used. Protection against disturbance is afforded by a base provided with four air cushions.

The author points out the important effects due to the back e.m.f. in galvanometers of this type and develops theoretically rules for max. sensitiveness as follows: The mechanical time-constant and damping should be equal to the corresponding electrical quantities; the back e.m.f. should be opposite in phase and equal to one-half the impressed e.m.f. When the galvanometer circuit contains only resistance, greatest sensitiveness is obtained when the natural frequency of the suspension is equal to the a.c. frequency. On the other hand, the a.c. frequency giving the largest deflection is lower than the galvanometer frequency for a circuit containing capacity, and higher for one containing self-induction. For resonance with the alternating current, the galvanometer is equivalent to a simple ohmic resistance. For a.c. frequencies lower than the natural frequency it acts like a self-induction, and like a capacity for the opposite case. The equivalent ohmic resistance at resonance may be very considerably higher than the d.c. resistance, its value increasing with the field-strength. The current sensitiveness in a high-resistance circuit increases with the field-strength. The volt sensitiveness in a low-resistance circuit (galvanometer shunted or short-circuited) rises to a maximum and then decreases as the field is strengthened, the condition for the maximum being, number of linkages = mechanical × electrical damping constant. The resonance curves where the circuit contains reactance are narrow but with very broad bases. Also if the field-strength is small the curves are extremely narrow, increasing in breadth as the field is strengthened. The resonance curve is also dependent on the circuit resistance, but this variation can be lessened by employing short-circuited turns on the spool.

The transient phenomena on first closing the galvanometer circuit are investigated and illustrated. The duration of these decreases as the field-strength is increased. The very important practical defects that arise from any lack of symmetry in the suspension, causing unintended oscillation about other axes than that of the suspension are also dealt with. Notes on the choice of a vibration galvanometer for use in a particular circuit conclude the article. A given galvanometer can often be used in a circuit for which it is not specially suited by connecting it to a transformer of suitable ratio.

W. H. G.

1462. *Quartz Mercury-lamp.* **W. T. Bovie.** (Am. Chem. Soc., J. 37. pp. 1721-1726, July, 1915.)—Describes a powerful mercury-vapour lamp in quartz, designed specially for use in biological and photochemical investigations. The principles of the mercury air-pump have been incorporated into the design so that no pump, other than an ordinary water aspirator, is required to exhaust the lamp to a very high vacuum. This feature not only does away with all troubles connected with the original exhaustion of the lamp, but makes it possible to re-exhaust the lamp quickly and easily at any time. The lamp can be re-exhausted without in any way disturbing the chemical substances under investigation and without interrupting the exposure for more than a fraction of a minute. The length of life of the lamp is, therefore, limited only by the durability of the quartz. A maximum of efficiency is obtained by constructing the apparatus so that the exposed substance receives practically all the light given out. The temperature of the substance is at all times under the control of the operator. Full details, with a diagram, of the construction are given. The lamp is operated on direct current, and takes a current of from 12 to 15 amps; with 110 volts an arc of about 9 in. can be maintained; with 220 volts the lamp burns with an arc over 2 ft. long. The solutions to be exposed to the light are contained in a triple-walled beaker, which surrounds the central quartz tube, 70 cm. long. The heat rays from the lamp are absorbed by a stream of water circulating between the two inner walls of the beaker. To test the lamp, eggwhite was diluted with water to make a 2 % solution. The solution was brought to its isoelectric point and filtered clear; 100 $cm^3$. of the filtrate were placed in the beaker of the lamp, and the water current was adjusted so that the solution had a temperature of 16°. A flocculent coagulum began to appear 4 mins. after the lamp was lighted. The lamp in this experiment was carrying a current of 11 amps. A. W.

1463. *Zeleny Electroscope.* **F. Horton.** (Phil. Mag. 30. pp. 381–388, Sept., 1915.)—J. Zeleny in 1911 described a new form of gold-leaf electroscope, specially suitable for lecture experiments with ionisation currents (Phys. Rev. 32. pp. 581–584, 1911). The novel feature of this instrument is that the ionisation current is measured by the period of vibration of the gold-leaf instead of by its rate of motion. In the present paper the author describes a modification in the design of this electroscope, a new method for the suspension of the leaf being suggested. A. B. W.

## ALTERNATING CURRENTS AND MAGNETISM.

1464. *Subsidence of Torsional Oscillations and the Fatigue of Nickel Wires in Alternating Magnetic Fields.* **W. Brown.** (Roy. Dublin Soc., Proc. 14. No. 39. pp. 521–528, June, 1915.)—Forms a continuation of previous work on this subject [see Abs. 788 (1911), 1027 (1914), 220 (1915) (in which the method of measuring the fatigue is given) and 801 (1915)]. The strength of the magnetic fields employed was 20 c.g.s. units in each case, the frequencies of the alternating fields being varied from 50 to 250 cycles per sec. The graphs of the alternating currents employed were practically pure sine curves, and throughout the present investigation the wires, 226 cm. long and 0·1675 cm. in diam., were subjected to the same load, viz. $1·5 \times 10^5$ gm. per $cm.^2$. The experiments show that a nickel wire of given rigidity can only be fatigued to a certain maximum amount by a magnetic field of a certain frequency, and the application of a field of higher frequency does not fatigue the wire *more* but fatigues it to the same max. extent in a shorter time. It appears that the time taken to effect the max. fatigue varies inversely as the frequency of the applied magnetic field. By testing the same wire after repeated annealing it is found that quite a small decrease in the rigidity of the wire produces a large increase in the damping of the torsional oscillations under a continuous magnetic field; in an alternating field the effect, while opposite in sign, is much smaller in amount.
J. W. T. W.

1465. *Galvano- and Thermo-magnetic Effects of Variable Conductors and Metals.* **J. Koenigsberger** and **G. Gottstein.** (Ann. d. Physik, 47. 4. pp. 566–572, July 8, 1915.)—A continuation of a previous paper [Abs. 1340 (1915)]. The galvano- and thermo-magnetic effects in the case of metals and variable conductors are in harmony with the modern electronic theory of metals; and, more especially, the effects show that the proper value for the number of electrons has been taken. The fairly constant value for the quotient of Hall-effect divided by resistance, shows that the mean free path is of the same order of magnitude in the case of all metallic conductors. The sign of the effects demanded by the theory are found to hold in the case of substances in which the internal magnetic fields are very weak. Further, the relationship required by the theory between the sign of the Nernst-effect and of the Ettingshausen-effect, and of the Hall-effect and Leduc-effect, is found to be valid; and for the Leduc and Ettingshausen effects the theory agrees well in respect of the magnitude. For a particular specimen of silicon, containing 5·2 % Fe, the following are the electrical constants: Hall-effect, $Bi = +120$ at 18°; Ettingshausen-effect, $+P = 2{\cdot}6 \times 10^{-8}$ degree at 18°; Nernst-effect, $Q = -3{\cdot}6 \times 10^{-2}$ at 47°; Leduc-effect, $+S = 3{\cdot}2 \times 10^{-7}$ degree at 47°; resistance, $R = 0{\cdot}056$ at 0°; heat of dissociation, $q = 670$; $\alpha = 0{\cdot}00521$; $\beta = 0{\cdot}000039$; thermoelectric force, Si-Fe $= -680$ microvolts at 34°; $-648$ microvolts at 72°. Thomson's heat, $\sigma = -1{\cdot}64 \times 10^{-4}$ at 55°; Peltier heat at 30°, 47 gm. cals. per coulomb Transversal increase of resistance in the magnetic field, $2{\cdot}6 \times 10^{-12}$ at 18°; change of thermal force in the magnetic field, $+3{\cdot}5 \times 10^{-11}$ at 34°. A. F.

1466. *Magnetisation by Rotation.* **S. J. Barnett.** (Phys. Rev. 6. pp. 171–172, Aug., 1915. Abstract of paper read before Am. Phys. Soc., Dec., 1914, and April, 1915.)—Does not permit of a short abstract—the original paper must be consulted [see Abs. 1585 (1912), 555 (1914)]. A. B. W.

1467. *Theory of Magnetism.* **J. Kunz.** (Phys. Rev. 6. pp. 113–125, Aug., 1915.)—A discussion of the subject which, after reviewing the experimental facts, dwells specially upon the periodic system of the elements and their magnetic properties. E. H. B.

1468. *Influence of Solar Eclipses on Terrestrial Magnetism.* **V. Carlheim-Gyllenskōld.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 10. 9. pp. 1–6, 1914.)—Details are given of the programme of magnetic observations prepared for the total eclipse of 1914 Aug. 21, in order to obtain data for the discussion of the influence of eclipses on terrestrial magnetism. Many causes for the effects have been suggested, the two chief being cooling of the air column along the shadow cone, and variation of ionisation by the local absence of sunlight. A map of the eclipse track is included, showing the various stations at which useful observations for the investigation could be secured, the localities being paired on either side of the track, and the hope is expressed that successful observers will interchange their results. C. P. B.

1469. *Résumé of a Magnetic Survey of Japan for the Epoch* 1913·0 *executed by the Hydrographic Office.* **T. Nakano.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 126–153, June, 1915.)—The previous survey for the epoch 1895·0 carried out by Tanakadate was confined to Japan proper, and since a large area has thus been unsurveyed, while the secular variations of the magnetic elements in this quarter of the globe require to be known, a complete survey has now been undertaken. The present report is a summary of the results obtained. The instruments used were the same four magnetometers as used in the previous work, and the total number of stations visited was 331. At each station the declination was observed for a complete day and so frequently as to enable the diurnal curve to be drawn. The diurnal mean was obtained by the planimetric method. The dip and horizontal intensity were observed generally 3 or 4 times, and the simple means of the results were taken, any reductions for diurnal variation not being applied. Methods and formulæ are given by which various reductions are made, and the results are summarised in 12 tables. The general agreement of corresponding values deduced in two different ways would appear to indicate the real existence of the annual acceleration of declination, at least so far as the order of magnitude is concerned. H. H. Ho.

## CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1470. *Some Appliances for Metallographic Research.* **W. Rosenhain.** (Inst. of Metals, J. 13, pp. 160–183; Disc. and Corres., 184–192, 1915. Mech. Eng. 35. pp. 244–246, March 26, and pp. 262–264, April 2, 1915.)—The author describes a number of improvements added to the metallographic equipment of the National Physical Laboratory. Specimens for microscopic examination are levelled by means of an optical instrument applying the principle of auto-collimation. A low-power microscope is provided with a side tube closed by a diaphragm with a small aperture and opposite the hole, a plane glass reflector is set at an angle of 45° in the tube of the microscope. The arrangement is so dimensioned that the distances from the centre of the reflector to the aperture and the principle focus of the objective are equal. Now if a perfectly plane reflecting surface be placed below the objective and the aperture be illuminated by a good light, a bright image of the hole will be formed on the cross-wires attached to the objective when the plane surface (a sheet of silvered plate-glass) is at right angles to the axis of the microscope. This is obtained by means of suitable levelling screws, and the specimen, mounted on plasticine on a micro-slide, is then laid on the reflector. The specimen is then adjusted until the image of the aperture again falls on the cross-wires, and then its surface must be parallel to that of the reflector. In order to attain a uniform rate of temperature-change during the taking of heating and cooling curves an electric furnace is wound at one end for 6 in. of its length, while the remainder (about 2 ft.) becomes heated by radiation and conduction. This gives a uniform temperature-gradient in the furnace and the specimen is slowly lowered or raised through the furnace by means of a motor and suitable reduction gearing. The rate of heating or cooling can be varied at will by altering the speed of the motor. A blank curve of such a furnace is practically a vertical straight line. As a first step towards making inverse rate curves self-recording the plotting chronograph has been devised. The detailed construction of the apparatus is somewhat complicated, but the following is a brief description of its principal features. The paper on which the curve is to be plotted is wound on a drum capable of being set round by a certain amount at definite temperature intervals. Moving at a regular rate parallel to the axis of the drum is a pen which can be caused to mark its position at any instant on the paper. When the spot of light from the galvanometer crosses certain positions on the scale the observer depresses the key of the apparatus. This causes the pen to mark its position on the paper, provides for the setting round of the drum and causes the return of the pen to the zero position in this sequence. With the object of eliminating the effect of the variation in the time of return of the pen during the plotting of peaks in the curve, arrangements have been made for a constant time-interval to elapse between the instant of marking by the pen and the commencement of its next outward journey. This time-interval has been made longer than the time taken for the pen to return from the longest journey it is likely to make. These operations have been accomplished by a most ingenious combination of electromagnets and contact breakers for a detailed description of which the original paper must be consulted. F. C. A. H. L.

1471. *Distillation of Liquid Air in a Magnetic Field.* **R. S. McBride.** (Am. Chem. Soc., J. 37. pp. 1715–1718, July, 1915.)—Distillation of liquid air from small Dewar tubes is found to proceed slightly more rapidly (5–10 %) when the tube is situate in a magnetic field of about 10,000 lines of force per cm.$^2$. This may be due to differences in the tubes themselves or in radiation and temperature conditions, or to increased liquid surface caused by attraction of the liquid towards the poles. In each of the limited number of experiments made, less oxygen distilled over during the early stages of the distillation in the magnetic field than in a similar distillation outside the field. T. H. P.

1472. *Extraction and Separation of the Radio-active Constituents of Carnotite.* **H. M. Plum.** (Am. Chem. Soc., J. 37. pp. 1797–1816, Aug., 1915.)—In view of the increasing demand for radium any research which will point out efficient and practical methods for the recovery of this element will be of both scientific and practical value. This paper presents the results of a critical investigation of various methods of treating carnotite with the object in view of extracting not only Ur, V, and Ra, but also its other long-lived radio-active constituents, ionium, RaD, RaF, and actinium. Several of the commercial methods now in use for removing vanadium and uranium from a carnotite ore have been examined and modified so as to be effective in treating ore which was found to contain quantities of vanadiferous silicate. In the method finally adopted the Ur is removed by boiling the carnotite concentrates with a sodium carbonate solution, precipitated as uranyl sodium carbonate by merely concentrating the filtrate, and the soda is again recovered. The radium, actinium, and radio-lead are contained in the filtrate obtained by boiling the residue (insoluble in soda solution) with hydrochloric acid. That part of the radium still held in the residue is then removed with boiling nitric acid. The ionium is finally recovered from the residue by boiling with sulphuric acid, and is then concentrated with cerium rather than with thorium (from which it cannot be separated).

A. B. W.

1473. *Ozonisation of Liquid Oxygen by Radiation.* **E. Warburg.** (Deutsch. Phys. Gesell., Verh. 17. 10. pp. 194–197, May 30, 1915. Communication from the Physikal-Techn. Reichsanstalt.)—The ozonisation of gaseous oxygen by ultra-violet rays, observed by Lenard in 1900, is feeble at ordinary pressure, but becomes stronger at high gas pressure (Kreusler). The author works with liquid oxygen or air in quartz tubes and with sparks between zinc electrodes. The empty quartz tube permitted partial transmission of the whole zinc-spark spectrum between 0·208 and 0·332 $\mu$; 1·5 cm. of liquid air absorbed the spectrum up to 0·256, the same thickness of liquid oxygen up to 0·261 $\mu$. Thus liquid oxygen behaved like the compressed gas of Dewar and Liveing. The ozonisation of the liquefied gas can be proved by means of potassium iodide and with the aid of the quartz-spectrograph and a plate of uranium glass. The lines between 0·277 and 0·280 $\mu$ were visible immediately after commencing radiation, but the whole spectrum up to 0·29 $\mu$ was blotted out after 9 minutes, whilst the group of lines about 0·332 $\mu$ was not weakened. It is possible, however, that O and $O_3$ have similar absorption spectra. H. B.

1474. *Change of Phase under Pressure.* II. **P. W. Bridgman.** (Phys. Rev. 6. pp. 1–33, July, and pp. 94–112, Aug., 1915.)—Melting-point data for nine further substances have been obtained for the range 0–200° and from atmospheric pressure to 12,000 kg./cm.$^2$; bismuth has been investigated to 270°. The results confirm the conclusion previously drawn [Abs. 1680 (1914)], namely, that unless there is a reversal at high pressures of the effects found up to 12,000 kg./cm.$^2$, the melting-point curve continues to rise indefinitely with pressure and temperature, there being neither a maximum nor a critical point. The equation to the melting curve is obtained in terms of the difference of compressibility, thermal expansion and specific heat between solid and liquid, and it is shown that a moderately good approximation to the difference of compressibility between solid and liquid may be arrived at by assuming that the difference between the specific heats is zero. These approximate differences of compressibility are given as a function of the pressure for all the substances of which the melting curves have been hitherto obtained. It is thus found that liquid and solid approach one another more rapidly in compressibility than in volume. In those cases where the necessary data are available, the most probable values of the differences of thermal expansion and specific heat at atmospheric pressure are discussed. T. H. P.

1475. *Constitution of the Copper-Tin Alloys.* **J. L. Haughton.** (Inst. of Metals, J. 13. pp. 222–242; Disc. and Corres., 243–248, 1915. Engineering, 99. pp. 419–422, April 9, 1915.)—Gives four previously published equilibrium diagrams of the Cu-Sn series, and points out the divergences in different parts of the field, these being divided into 6 groups. The present paper contains the results of an investigation of the $\epsilon$ constituent, this being only one of the 6 points requiring reinvestigation. The $\epsilon$ constituent was not shown on the diagram of Giolitti and Tavanti; Heycock and Neville showed the isolated constituent, which they called H, as existing along a line sloping from 61·1 to 65 per cent. Sn; Shepherd and Blough showed it as a narrow strip having at 400° a composition of 59·5 to 60·5 Sn and at 0° 59·5 to 62 Sn; whilst Hoyt gave its temperature of formation 500° with a range in composition from 47 to 50 per cent. Sn at 300°. Full details are given of the thermal treatment, including quenching, with a view to obtaining a fine structure, and annealings at different temperatures from 210° to 415°. The results of microscopic examination and records of heating curves are also given and discussed. As a result of this work a diagram is given showing the position of the $\epsilon$ constituent and its immediate neighbours. This differs from Heycock and Neville's diagram in showing the composition of the first formed $\epsilon$ to be 59 per cent. Sn instead of 61·1 Sn, the temperature of formation as 415° instead of 400°, and the line of formation as meeting the eutectic line at 60 per cent. Sn instead of 65 per cent. Sn. C. O. B.

1476. *Some Experiments upon Copper-Aluminium Alloys.* **J. H. Andrew.** (Inst. of Metals, J. 13. pp. 249–260; Corres., 261–262, 1915. Engineering, 99. pp. 444–447, April 16, 1915.)—Differential and direct cooling curves are given of a series of alloys containing from 9 to 20 % Al in order to decide some points of difference in the equilibrium diagrams of Carpenter and Edwards [Abs. 1711 (1907)] and of Curry. As a result of the experiments certain corrections to Curry's diagram are suggested and a new diagram is given embodying these corrections. It is also shown that the point at 290° found in the cooling curves of Carpenter and Edwards is due to the incomplete decomposition of $\beta$ into $\alpha + \delta$. C. O. B.

1477. *Micro-chemistry of Corrosion.* III. *The $\alpha$-$\beta$ Alloys of Copper and Zinc.* **S. Whyte.** (Inst. of Metals, J. 13. pp. 80–90; Disc. and Corres., 91–99, 1915. Engineering, 99. pp. 322–324, March 19, 1915.)—This paper deals with the corrosion of brasses containing both the $\alpha$ and $\beta$ constituents—that is, alloys of the Muntz-metal class. As in the case of the previous researches, an applied e.m.f. was employed to hasten corrosion, and the results obtained when compared with actual cases found in service confirm the opinion that in all cases the nature of corrosion is primarily dezincification. Five α-β alloys were used: one in the unannealed state, one after annealing at 575° C., and others annealed but containing iron, lead, and tin respectively. There were two series of experiments carried out. In the first the current was continued for 5 mins. and the products were separated into "precipitate," which is of a flocculent nature and appears in the electrolyte, and "adherent layer," this latter being found in most cases to consist of metallic copper mixed with zinc oxychloride. In the second series, 100 cm.$^3$ of electrolyte were made to flow over the surface in 60 mins.

It was found that the β constituent was attacked first; the first change in the areas of β is the appearance of minute pits which gradually give way to a smooth bright copper layer covering the surface of the β, and not until this is complete is the α attacked. On further corrosion the surface of the alloy does not become a layer of copper of uniform thickness, since the action still penetrates the β crystals more quickly than the α crystals.

By examination of a bolt which had been immersed in sea-water for a considerable time, it was found that the α and β constituents were replaced by copper—that of the β areas being porous and of a dark-red colour, while that of the α areas was of a bright light colour.

As a result of the research it is concluded that the total corrosion of the α-β alloys is much less than that of the β alloys but more than that of the α alloys. The unannealed alloy is dezincified more than the annealed one, and the total corrosion is also decidedly more.

The alloys containing iron and lead show more corrosion than the annealed alloy, whilst the alloy containing tin shows an increase over the annealed alloy in a 5-minute test but a decrease in a 60-minute test, this being due to the retarding action of the tough layer of basic salts (including tin) which is formed. C. O. B.

1478. *Commercial Production of Sound, Homogeneous Steel Ingots and Blooms.* **E. Gathmann.** (Am. Inst. Mining Eng., Bull. 104. pp. 1485–1492, Aug., 1915.)—The author gives further details of his process for the production of sound ingots [see Abs. 1358 (1913)]. In order to produce sound, homogeneous steel ingots it is first necessary to treat the steel in the furnace, ladle, and mould so that piping steel is produced. By the application of moulds of a suitable design (increasing in wall thickness from top to bottom) the author confines this pipe to the upper 20 % of the ingot. By the use of a sink-heat of poor heat-conducting material it is possible to reduce the amount of cropping required to 12 or even 10 % of the ingot. These remarks apply to the "small end up" method of casting. In casting "big end up" still better results can be obtained, normal practice requiring a crop of only 5 %. The author considers that the prime essential for the production of sound, homogeneous steel lies in the thorough deoxidation of the molten steel before pouring it into the mould. F. C. A. H. L.

1479. *Researches on the Iron, Silicon, Carbon Alloys.* **G. Charpy** and **A. Cornu-Thenard.** (Iron and Steel Inst., J. 91. pp. 276–300; Corres., 303–305, 1915. Engineering, 100. pp. 173–177, Aug. 13, 1915.)—Thermal, dilatometric, chemical and microscopical analyses have been carried out on a number of series of alloys containing varying percentages of carbon and silicon. The results show that Si decreases the intensity and increases the temperature of the A3 transformation. As the Si increases, the temperature of A2 is lowered while that of A1 is raised, until finally A1 occurs at a higher temperature than A2 on cooling. In dead-mild steels these two points merge into each other at 3·16 % Si and become inverted when the Si reaches 4 %. Microscopic analysis shows that in high-Si alloys the whole of the carbon can be precipitated in the graphitic state at temperatures depending on the carbon-content of the steel. The temperature is about 800° C. in the dead-mild steels, and about 850° in the medium steels. Cooling curves of the graphitised alloys show that the A1 point is completely suppressed and only the A2 point appears on cooling from temperatures below 900° C. On cooling from above 950°, A1 reappears owing to the re-formation of cementite. Experiments on high-carbon (2 %) alloys indicate that Si gradually decreases the solubility of carbon in iron. The solubility becomes practically nil at 900° in a 5 % Si alloy and at 1000° in alloys in which the Si exceeds 7 %. The influence of Si on the rate of reaction is so great that in certain irons the graphite precipitation gives rise to thermal disturbances. The A2 point produces no disturbance in the dilatation curves, but the fact that it is possible to obtain it most distinctly in alloys from which A1 is absent is strong evidence in favour of its being a separate allotropic transformation. F. C. A. H. L.

**1480.** *Iron, Carbon, and Phosphorus.* **J. E. Stead.** (Iron and Steel Inst., J. 91. pp. 140–181; Disc. and Corres., 182, 198, 1915. Engineering, 99. pp. 569–572; Disc., 563–564, May 21; 611–613, May 28, and pp. 637–641, June 4, 1915.) —This paper consists of three Sections. In Section I a review is given of the work published in recent years on the alloys of iron, carbon, and phosphorus. In Section II more recent research is recorded, while Section III is devoted to a description of a new method for detecting variations of phosphorus in iron and steel.

In Section II the results of further studies of blast-furnace bears are given in which the elimination of phosphorus by pressure due to slow cooling and contraction is again illustrated. The conditions favourable for the separation of idiomorphic crystals from solid solutions of phosphorus in iron, such as those found in meteoric iron, is discussed. It is pointed out that there must be a range of temperature in which the phosphide crystallises out of the solid iron, but what this range is has not yet been discovered. The unequal distribution of phosphorus in the metals taken during the "after-blow" in a basic lined converter is considered and illustrated by photomicrographs. It is found in test ingots that when there are large crystals, some containing phosphorus and others of purer metal, although forging shatters both of them, the first do not readily recrystallise, while the latter do. It is the presence of parts not recrystallised in the fractured test-pieces which indicates to the Bessemer blower that phosphorus is not sufficiently eliminated and that further blowing is necessary. Although the phosphorus is almost perfectly distributed in blown Bessemer metal containing practically no carbon and 0·3 % P, it is not so when appreciable amounts of carbon are present. It is found that as carbon is increased in fluid metal, the phosphorus becomes more and more concentrated in the portions last to solidify. For example, in very grey hematite iron the phosphorus is concentrated in independent nuclei in the form of a eutectic containing from 7 to 10 %, whilst in the purest steels containing from 0·4 to 1·5 % carbon, the phosphorus is found in concentrated solid solution in and about the crystals and never as free phosphide.

The results of experiments are given on the synthetic production of "ghost lines" in steel by heating powdered iron-phosphorus carbon eutectic between sheets of soft iron to 1000° C. and then forging down. The structure obtained is found to be identical with that often found in ship- and boiler-plates, consisting of strings of disconnected patches of pearlite and straight lines of ferrite. The results of experiments on a soft steel plate are given which prove that the parts rich in phosphorus constitute the white "ghost lines," and that they are the last to be invaded by carbon on heating up and the first to part with carbon on cooling down.

The method given in Section III for detecting variations of phosphorus in iron and steel consists in the use of a reagent made by mixing 10 gm. cupric chloride, 40 gm. magnesium chloride, dissolving in hot water, adding 20 cm.$^3$ hydrochloric acid and making up to one litre with alcohol. The specimens are simply covered with a thin layer of the reagent and must not be immersed in the bath. The layer of liquid, after remaining on the suface for 1 min. is shaken off and a second layer dropped on the surface, and left there for the same period. This procedure is repeated as often as it is found necessary. The specimen is washed with boiling water, then with methylated spirit and shaken to remove the spirit from the surface, the heat imparted by the boiling water rapidly evaporating the last traces of alcohol. The copper is usually left as a hard, coherent layer, and is not readily removed by rubbing. In using this reagent it is found that copper is invariably first deposited on the purer portions containing least phosphorus, and so sensitive is the reagent that differences of 0·01 % P can be detected. C. O. B.

**1481.** *Recent Progress in Corrosion Resistance.* **D. M. Buck.** (Mech. Eng. 35. pp. 491–493, June 18, 1915. Abstract of paper read before the Am. Iron and Steel Inst., New York, May, 1915.)—The results of several years' work on the corrosion of sheets of iron and steel of varying compositions when exposed to atmospheric influences have led to the following conclusions as regards the effects of the various constituents on the resistance to corrosion. The amounts of carbon, manganese, silicon, and phosphorus normally present in iron and steel have a negligible influence on the resistance to corrosion. Sulphur stimulates corrosion, but the deleterious effect of 0·14 % can be neutralised by the presence of 0·25 % of copper. Addition of small amounts of copper, even 0·04 %, has a great influence in lowering the rate of corrosion. This influence is increased up to a content of 0·15 % of copper, but there appears to be very little if any advantage gained by increasing the copper-content above 0·25 %. The beneficial effect of copper appears to be bound up with the production of an initial rust-film of very close texture.

F. C. A. H. L.

**1482.** *The Diffusion of Carbon in Iron.* **F. W. Adams.** (Iron and Steel Inst., J. 91. pp. 255–268; Corres., 269–270, 1915. Engineering, 100. pp. 95–97, July 23, 1915.)—During the experiments described in this paper the previously observed fact was again noted that iron and steel when heated *in vacuo* above 900° lose weight. It is further shown that samples of steel, white iron, and, to a less extent, grey cast iron, will weld together when heated *in vacuo* within the temperature-range 900° to 1000° provided their surfaces are clean and in perfect metallic contact. The amount of this welding or intercrystallisation thus taking place is not dependent on the quantity of carbon present in them, nor on the difference of carbon content of the two specimens, but only on the perfection of contact between their respective surfaces. When welding occurs between two specimens of iron of unequal carbon-content the transference of carbon by diffusion is much more rapid than the transference of carbon effected by the agency of a gaseous vehicle, such as carbon monoxide. C. O. B.

1483. *Potential of Silver against Silver Ion in Concentrated Solutions of Potassium and Sodium Chlorides, and its Relation to the Activities of such Solutions.* **G. S. Forbes** and **F. O. Anderegg.** (Am. Chem. Soc., J. 37. pp. 1676–1685, July, 1915.)—The activity of the chloride ion in concentrated solutions of sodium or potassium chloride saturated with silver chloride is calculated from potential measurements in which silver electrodes were employed and diffusion potentials were eliminated by means of a junction of concentrated potassium nitrate solution. The solubility product is assumed to be constant, evidence being furnished to show that its variations do not greatly affect the conclusions drawn. The values obtained by this method are always smaller than those calculated from conductivities, excepting with the most concentrated solutions of sodium chloride; the dissociation calculated from them reaches a minimum at the concentration 1·7 N. The results given by solutions of constant silver chloride content but containing varying proportions of the alkali chloride support the hypothesis that the complex $K_3AgCl_4$ exists in solutions of greater concentration than 1·7 N. T. H. P.

1484. *Potassium Chloride Concentration Cells.* **D. A. MacInnes** and **K. Parker.** (Am. Chem. Soc., J. 37. pp. 1445–1461, June, 1915.)—The e.m.f.'s of the cells without transference :—

$$\mathrm{Ag} \;\Big|\; \underset{C_1}{\mathrm{AgCl, KCl}} \;\Big|\; \mathrm{K(Hg)}_x - \mathrm{K(Hg)}_x \;\Big|\; \underset{C_2}{\mathrm{KCl, AgCl}} \;\Big|\; \mathrm{Ag}$$

have been measured and compared with measurements of the voltage of the cells with transference.

$$\mathrm{Ag} \;\Big|\; \underset{C_1}{\mathrm{AgCl, KCl}} \;\Big|\; \underset{C_2}{\mathrm{KCl, AgCl}} \;\Big|\; \mathrm{Ag}$$

With the same solutions in cells of both types, the ratio of the potentials is shown to give accurate values of the transference number of the kathion. The measurements indicate that the "activities" of the ions from potassium chloride are much lower than the concentrations as calculated from conductance measurements. The values of the "activity" and of the concentration, however, apparently approach the same limit for very dilute solutions.

T. M. L.

1485. *Electromotive Forces in Alcohol.* VI. *Absolute Potentials by the Capillary Electrometer.* **E. Newbery.** (Chem. Soc., J. 107. pp. 852–857, June, 1915.)—Figures given by the dropping electrode for the absolute potentials of the mercury electrode in alcoholic solutions [Abs. 870 (1915)] are untrustworthy. Better values have been obtained by the capillary electrometer as follows :—

*Absolute Potentials of Mercury.*

(*a*) In a saturated alcoholic solution of sodium chloride, 0·488 volt at 20°.
(*b*) In a saturated aqueous solution of sodium chloride, 0·481 volt at 20°.
(*c*) In a normal aqueous solution of sodium chloride, 0·581 volt at 20°.
(*d*) In a decinormal aqueous solution of sodium chloride, 0·580 volt at 20°.

The values for 25° are 0·485, 0·483, 0·534, 0·584.

Values are also given for solutions of ammonium chloride in alcohol and in water. T. M. L.